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Edited at the Massachusetts Institute of Technology

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Technology Review

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First Line

Plugging Into Photovoltaics

In our June/July issue (*page 64*), we have Leon R. Glicksman, the author of an otherwise literate and informative article on heat pumps, writing that "the annual cost of one million barrels of oil at $13 per barrel is only about $13 million." Dr. Glicksman's muddy phrase was not in his original manuscript; there he made clear that one million barrels of oil is the U.S. *daily* consumption and $13 million the daily cost, bringing the annual cost to nearly $5 billion. Dr. Glicksman's point was to compare this with the capital cost of solar collectors to realize equivalent energy ($150 to $300 billion), and he rightly concludes that the "return on the investment in solar collectors . . . is unacceptably long."

Many *Technology Review* readers were surely able to make their way through our foolishness without any help, though it's not our intention that they have to. But this raises in an unintended context a question which has been much in the editors' minds while preparing the current issue: To what extent are our readers ready to draw on a background of basic understanding and motivation in physical science to deal with details of nascent technologies as well as the implications and policy issues embodied within them?

The case in point is on pages 14-36 of this issue, where John C. C. Fan undertakes to describe the physics by which sunlight is converted into electrical current in a photovoltaic material. It's a complex subject, full of abstractions — for example, how semiconductors work by the movement of electrons and holes through junctions. Many readers, we think, should welcome a detailed and lucid exposition of photovoltaic principles and dynamics. So we encouraged — and tried to help — Dr. Fan in a very difficult assignment; and we'll welcome readers' judgments of both the success and the usefulness of the effort. — *J.M.*

Letters

Solar House Design

Mark Hyman's article in the February issue describing his solar house raises two points. First, I think the article conveyed a rather neutral, unenthused attitude towards solar energy utilization based on the cost. Perhaps the initial cost of the system could have been less. His aim was to design a solar system for New England, not the southwest, and one criterion was that the house fit into a neighborhood of traditional homes. However, his is a solar house only because it has a solar system. From what I can observe, no effort was made to design the house around a planned use of solar energy.

For example, of 22 windows I counted, 14 are northernly oriented: eight are on the north side of the house, exposed to northern winds and little or no sun; six more are on the east and west sides, but in the northern half, again exposed to winds and more limited, sharply-angled sunlight. The number of windows and their arrangement allow for substantial heat loss. It is quite possible to design a traditional house to take more advantage of the site.

In addition, I wonder about using fewer collectors more consistently and letting the pool temperature be driven higher. Although these measures might result in a system that is less responsive, it could cut hardware costs (not only by reducing the collectors needed) but also by reducing the number of radiators. This would also provide an additional passive component. By having a pool that has easily removable and replaceable insulation on the top, heat could be deliberately leaked into the living area above, especially at night.

The second point is that outfitting a house for solar energy is more than a venture in economics. The decision to use the sun's energy should be based on more than a 20- or 30-year payback period, or the eventual rise in fossil fuel prices. I think investing in solar hardware is a very real statement of a belief, or at least an active desire for an acceptable future. It shows a personal willingness to start moving on the right road now, even though there is time left on the road of fossil fuels.
Fairleigh Brooks
Louisville, Ky.

Mark Hyman replies:
It is quite true that a more energy-conservative house could be designed. One could have fewer and smaller north-facing windows; one could have an earth beam covering part of the first floor exterior. However, we opted for the view to the north and for summer breezes in all directions. We do have two sliding glass doors facing south which provide appreciably more southern glazing than north-facing. But windows do represent a substantial heat leak and this is a field crying for further research and development.

The Voyagers of Noah's Ark

David Salisbury states at the end of his article (*"Animal Liberation," May, 1978*) that "the doctrine of animal rights is a natural marriage of evolutionary theory and Western morality." With the evidence before us regarding Western morality I don't see much hope for this marriage. I do see that a closer examination of the Hebrew-Christian Scriptures reveals God's loving concern for all His creation. It wasn't until Greek philosophy impacted Judeo-Christian thought and ethics with the concept that "spirit" was vastly superior to "matter" that Western man began to act casually toward God's creation. With the current re-examination of Scripture and a trend toward personal piety and responsibility, animal rights will take their place, but not due to the marriage of a theory and a concept.

Salisbury's article creates an awareness for those who are moved to act responsibly and in love toward God's creation and His order. Dr. Fox's guidelines need to be put into action. We now need to know how to implement them.
Harry J. Sommer
Lafayette, Calif.

David Salisbury's column regarding humane treatment of animals supports a very worthy cause. However, his philosophical basis is suspect. Evolutionary theory destroys, rather than supports, "Animal Liberation." The "survival of the fittest" surely means the weak (animals, in this case) are only pawns of the strong.

The real basis of humane treatment is the Judeo-Christian faith which stresses our responsibility for all of God's creation, including animals. Specifically, see Deuteronomy 22:1, 4, 6, 7, and 10 and 25:4. These first laws defining humane treatment for animals existed about 3,000 years before any other civilization (England in the 19th century) had any such laws. Typical of the Judeo-Christian faith, those in authority (mankind) bear great responsibility for those in their dominion.
Richard A. Crowell
Boston, Mass.

A Niche for Nuclear Wastes

Having recently finished "Nuclear Waste Disposal: Not in My Backyard" in the March/April issue, I am concerned that an important option has been entirely omitted from this discussion.

The risk to earth's biosphere can be reduced to zero by only one method: the complete removal of radioactive wastes from the biosphere. The most obvious means of doing this is to transfer the wastes to near earth orbit by Space Shuttle and from there to move them to a nearby gravity well in order to prevent accidental reentry. Even the most ardent paranoid should admit that this is safe from the standpoints of both natural and manmade disasters.

It is easily the safest possible answer though, unfortunately, the most expensive. I estimate that using 1980s technology it would cost approximately $400 per pound to transport these wastes to the moon. If the long-lived radioactive isotopes were concentrated as much as possible before transporting them, the actual mass transported would be far less than that now stored in reactor pools.
Jefferry King
Cincinnati, Ohio

The article by Alan Jakimo and Irvin C. Bupp on nuclear waste disposal is very comprehensive, but omits the possibility that radioactive by-products may finally prove to be an asset, rather than a liabil-

ity. This may seem surprising, but, after all, it could seem surprising to an ape, to find out that fire could be an asset.

In perusing the chart of elements, one finds that most have been put to good use. Why should the nuclear waste elements be different?

Kenneth J. Epstein
Chicago, Ill.

The Nuclear Squeeze

Upon hearing another speech by Jack O'Leary, Deputy Secretary of the Department of Energy, I was spurred to respond to a few points in David Salisbury's assessment of the siege on nuclear power in your March/April issue.

The utilities are not as weak as Mr. Salisbury implies. The economic recession and drop in load growth has not significantly damaged their resources because the energy generated has had the benefit of newer and more efficient plants. Rather, those utilities that are financially squeezed today are so because of the reluctance of state regulatory commissions to grant sufficient rates to provide an adequate return on investment.

Secondly, I have little doubt that if and when nuclear orders pick up again there will be companies ready to supply the equipment. However, it is clear that if some of the current vendors disband, the result will be more costly equipment and less competent engineering than would have resulted from orderly growth.

Our own analysis shows that the coal alternative is becoming almost as capital-intensive as nuclear, but the nuclear fuel cycle still gives it the advantage. It is the uncertainties in licensing and the threat of indeterminant delays, rather than capital problems, which are the most serious deterrents to nuclear commitments. Yet by the same token, many utilities are not clear whether they can site and obtain the necessary permits for coal-burning plants anymore!

One of the most ironic arguments that Amory Lovins and other critics use is the charge that the capital cost of nuclear plants is too great. But Ian Forbes and others who have looked at Lovins's soft path find that the capital requirements are 300 per cent that required for the traditional path!

The appalling thing to me is that Jack O'Leary can stand up before a knowledgeable audience, review the problems facing the nuclear industry, and then look at his audience and say to us, "*You* are in trouble!" The nation is in serious trouble! And the Deputy Secretary of the Department of Energy, who has a mission to do something about it, does nothing more than list our troubles and wave a warning finger at an industry that is badly besieged.

A. David Rossin
System Nuclear Research Engineer
Commonwealth Edison
Chicago, Ill.

Neutron Bomb: Tactical or Impractical

The article "Enhanced Radiation Warheads, Alias the Neutron Bomb" in your May issue provides an excellent history of the development of the ERW. Unfortunately Professor Kistiakowsky's analysis of the ERW's tactical uses does not succeed as well. The following points should be made:

It is unlikely that the Soviets will encumber their vehicles with a 10 cm layer of water and a "thin" layer of cadium, and thereby limit the range of an ERW explosion. Besides being expensive, it would be ineffective. If placed on the tank's exterior, the shielding would be damaged by indirect fire or the wear and tear of travel. Inside the tank, the bags would reduce an already cramped area needed for the combat load. In either case, the shielding would hamper visibility and present severe operating limitations.

Professor Kistiakowsky is inaccurate when he states that "veritable neutron bomb barrages" would be used to destroy a Soviet attack. The controls imposed on the use of any nuclear weapon, N.A.T.O.'s express policy of using nuclear weapons as a last resort, and the predicted Soviet strikes against nuclear arsenals make this reaction an impossibility. Given that the employment of nuclear weapons are directed by division and higher headquarters, the ERW will be used only against significant Soviet forces and then sparingly.

The ERW is a defensive weapon. It is most effective against mobile forces, but positioned forces have little to fear from ERW — soldiers and civilians can hide in cellars or other fortifications. Also, I question that with modern conventional weapons "what can be seen will be hit, and what will be hit will be destroyed." Leaving aside the problems of smoke and camouflage tactic at which the Soviets excel, other advantages from numerically superior Soviet artillery significantly degrade N.A.T.O.'s ability to see, hit, or kill.

N.A.T.O. must maintain a viable nuclear option to counter the Warsaw Pact. The Soviet buildup, despite Congressman Aspin's inaccurate analysis, is rapid and threatens the peace in Europe. ERWs, by lowering the threshold of nuclear war, raise the threshold of any war starting in Europe.

Donald Wilkins
1st Lieutenant
U.S. Army Signal Corps
Savannah, Ga.

Twenty-two years have now passed since I relinquished command of our 503rd Airborne Infantry Regiment in Munich, then the easternmost N.A.T.O. ground unit with a "hold at all costs" mission for the more than one-hundred-mile front from the Danube to the Swiss border. We were prepared for the combined assault of three Czechoslovak divisions with some three hours warning. We were also charged to withdraw "only under pressure" to a defensive position on the West bank of the Rhine "holding our losses to a minimum." I pray that no American nor Allied infantrymen will ever really have to enact this or any similar mission.

That there has been no hostile advance into Bavaria for these 22 years is the result of many factors. We all need practical analysis of this situation. Professor George Kistiakowsky's discussion of the neutron bomb was just such an analysis. We need to sustain this effort. If war is too important to leave to the Generals, then the prevention of war is certainly too important to leave to any special group. The problem belongs to us all.

William S. Hutchinson, Jr.
Colonel, U.S. Army, Retired
Jacksonville, Fla.

Measures of Prevention

I was interested to read in May's Trend of Affairs, page 21, of J. Daniel Nyhart's efforts to "cost out" the expenses of regulating air, water, and noise pollution and safety. He's right, by God! These do-gooders should be made aware of how much their interferences are costing American industry. But Professor Nyhart's balance sheet is one-sided. The cost of instituting the regulations has to be balanced against the expenses which will be incurred without them. I identify six kinds of saved expenses:

☐ Health care to those injured by pollution or lack of safety. Presently this cost falls on the individual or on society in general, as opposed to the actual causer of the injury, but the cost must still be counted in.

☐ Loss of productivity by the injured individual(s).

☐ Expense of litigation when the injured attempt to recover, or when society later attempts to remove the source of the danger.

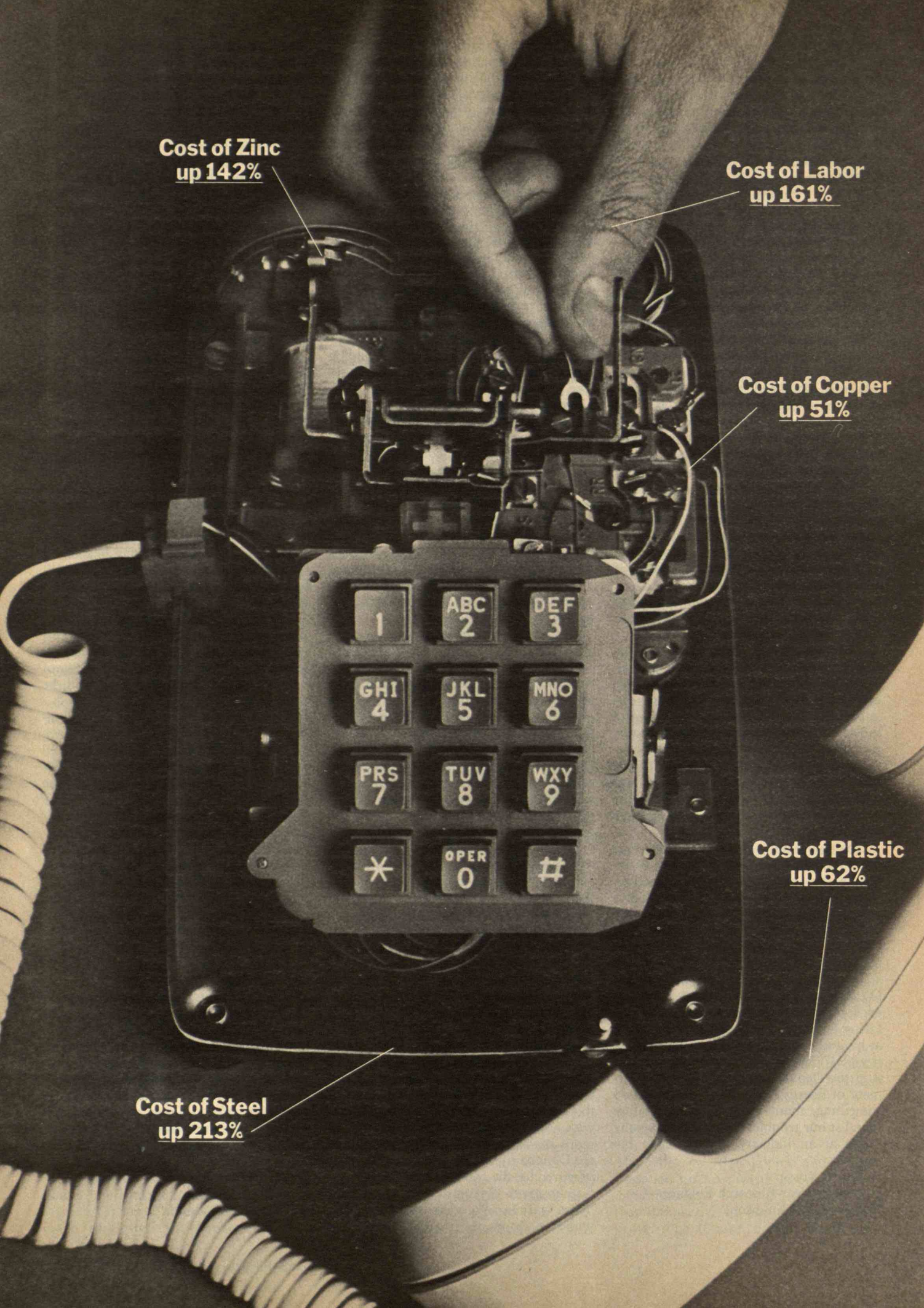
☐ Impairment or destruction of other industries or commercial products as a direct or indirect result of pollution or lack of safety. For example, damage to the fishing and seafood industry when the waters of the entire Chesapeake Bay were recently poisoned by the pollutant Kepone. All seafood from the bay is expected to be inedible for twenty years.

☐ Emotional stress to the injured and their families.

☐ Death benefits, funeral expenses, etc.

Columnist Robert Cowen in the same issue suggests that polluting the atmosphere with CO_2 might cause melting of the polar ice caps and flooding much of the coastal land mass as a result. If pollution controls are effective, this dreadfully expensive cataclysm may be avoided, and the savings in prevention should definitely be included in Professor Nyhart's calculations.

Deloss Brown
New York, N.Y.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up 161%
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up 51%
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up 62%
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Advocates Cloud Issues in Science

Robert C. Cowen, Science Editor of the Christian Science Monitor, *won the 1977 A.A.A.S.-Westinghouse Science Writing Award. He is former President of the National Association of Science Writers and is a regular contributor to the* Review.

Many scientists are on the defense these days about their profession's "public image." Though the scientific community has felt the need to prove itself in the past, that need seems especially acute now that program cutbacks threaten to eclipse scientists' expectations and the limelight has been turned on the debates over the dangers of a few technologies or lines of research.

Those scientists who are rallying for their profession blame the press for distorting the public view. "You might think, to read the papers on some days, that the scientists are ready and eager to take the world over and run it to their liking, filled with hubris, knowing everything about everything," observed Lewis Thomas, president of the Sloan-Kettering Cancer Center. And Cornell University astronomer Carl Sagan complains that scientists are portrayed to children on television as "moral cripples . . . and the message conveyed to the moppet audience is that science is dangerous."

These are legitimate concerns. But it was ever thus. As a "media person" myself, I doubt that bad reporting and silly television have succeeded in converting public opinion. In fact, national opinion polls prove the public thinks well of scientists. They outscored President Carter in a recent popularity poll. Recent National Science Board surveys in 1972, 1974, and 1976 discovered that "the public continues to have an overwhelmingly positive general reaction to science and technology." Only an estimated seven per cent of Americans thought science and technology have been detrimental while 71 per cent credited science and technology for improving the quality of life. Also, when asked to pick the offender in cases where science and technology have caused problems, 60 per cent of the public blamed government decision-makers. Only five per cent pointed to scientists and only seven per cent to engineers. Europe's showing was no different from the United States. A survey made for the Commission of the European Communities estimated 69 per cent of the public in nine countries believe that science has improved life.

Misplaced Concern

Scientists do have a special public relations problem at this time. But their concern about "image" is misplaced. It is not with the public *per se*, but with those who pre-empt reasoned discussion of the consequences of science and technology with the politics of advocacy and confrontation. What scientists see as their poor public image is an illusion created by the bloated visibility of scientist-advocates and public interest groups — and, yes, advocacy-journalists — who exaggerate legitimate concerns and distort scientific knowledge for political ends. This both confuses the public and exacerbates an existing skepticism about science and technology.

The skeptic's belief that the fruits of science can be misused is not unfounded, noted Nathan Keyfitz of Harvard University at an American Association for the Advancement of Science symposium on science's public image. Although many symposium participants brooded over the effects of "bad press," Dr. Keyfitz pointed out that the public has a powerful reason for distrust in the fact that much of science serves war: a quarter of American scientists' efforts and an even larger percentage of Soviet science are devoted to military ends.

While this healthy skepticism hasn't produced waves of antipathy to science, it is susceptible to manipulation when the issues are technically complex and the advocates are vociferous and, sometimes, unscrupulous.

The explosion of sentiment over recombinant DNA research is one case where the politics of advocacy reigned. DNA (deoxyribonucleic acid) is the molecule that carries the genetic programs of plants and animals. When molecular biologists developed ways to cut up these programs and recombine them in new patterns, they were the first to consider the possibility of their creating dangerous microbes. They adopted a voluntary research moratorium during which they established safe research guidelines. While most of the biologists involved merely wanted to take a good look at what they were doing and assure themselves of safe and sensible procedures, a few biologists scorned concern and resisted the impingement of governmental controls. Another handful wanted a complete halt on research activity until the philosophical questions of whether or not humans should "play God" with evolution were resolved.

Media Monsters Confuse the Public

However, once the issue was given these dramatic dimensions, it was usurped by politics, both at the national level and sometimes locally, as in Cambridge, Mass. "Concerned" scientific bystanders, such as chemist George Wald of Harvard University, stumped the country to warn of the "dangers" of such work. Public interest groups, such as Friends of the Earth, with little initial understanding of the subject, took up the cause, pressing for strong legal control of the research.

Meanwhile, microbiologists have concluded that the early concern was overly cautious. Nature routinely does far more recombining of DNA than they had realized. And the chances of their creating exotic pathogens are minuscule. Lewis Thomas pointed out that infectious microbes have had to evolve complex mechanisms to survive in a world where most bacteria and fungi live by browsing on dead matter. "It takes a kind of arrogance to assert that microbiologists can manufacture complicated creatures like these, by choice or by chance. On the other hand, the pure research potential of the recombinant DNA technique is simply tremendous. It does not exaggerate the case to say that this may be the greatest scientific opportunity for biology in this century," he said.

But now most microbiologists feel restrained by unnecessary laws regulating their research and hope for a relaxation of the guidelines administered in the U.S. by the National Institutes of Health. But the public interest groups are still hanging on. While Congress has withdrawn in confusion from passing any regulatory law this session, the pressure still hovers. Overseas, Holland has relaxed its guidelines. But Britain has put the research under strict government control, setting a precedent for government intervention in academic freedom to do basic research.

The microbiologists may have learned that they can't create test tube monsters after all. But they have inadvertently created a political monster. At this moment it is unclear whether or not that monster can be caged. The rhetoric of fear has confused public opinion to the point where an unnecessary degree of control of this research may be politically unavoidable.

Distorted Disclosures

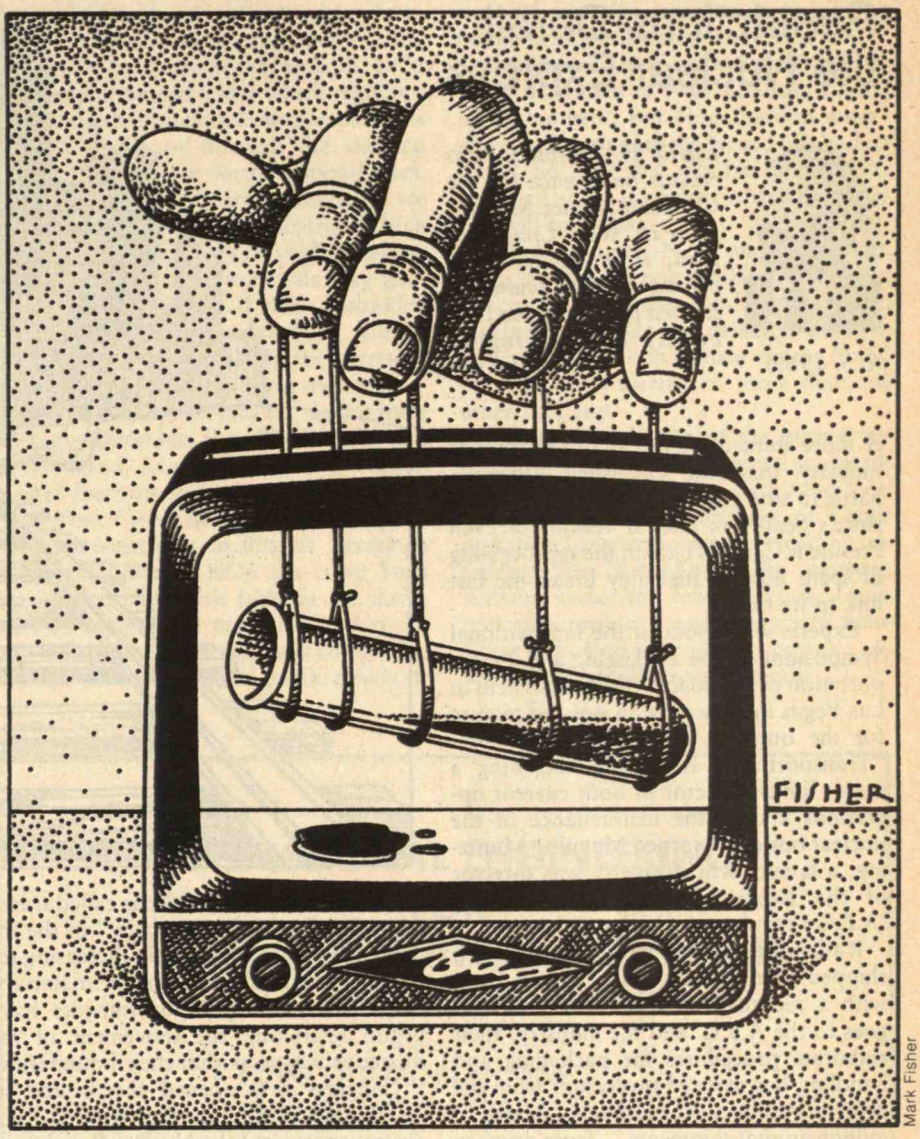
Nuclear power provides another example of a field where advocacy has all but suppressed reasoned debated. The Atomic Industrial Forum complains that a Washington newspaper columnist misrepresented the Nuclear Regulatory Commission's Reactor Safety Report (prepared under the direction of M.I.T.'s Norman Rasmussen). The columnist claimed the report identified a core meltdown as the most likely type of reactor accident, with release of 1,000 times more radioactivity than a Hiroshima-type atomic bomb. The report says no such thing. But Washington columnists don't read technical tomes. They do get both ears full of the fearmongering of anti-nculear advocates who, through ignorance or guile, often distort such reports.

Or consider the "hazard" of eating pan-fried hamburgers. Last spring, Barry Commoner's laboratory at Washington University in St. Louis reported work in which they gave hamburger, cooked various ways, the Ames test. This test uses bacteria to detect possible mutagenic (which implies carcinogenic) effects. Test of hamburgers grilled or cooked in microwave ovens were essentially negative. Tests of meat pan-fried or cooked in electric hamburger cookers were positive. Dr. Commoner's report noted that this did not imply that these latter cooking methods made hamburgers carcinogenic. It merely raised suspicions that should be checked out by more thorough research.

That's all very clear. But Dr. Commoner sent announcements of his work to the press before giving the technical paper. The reporting that followed often failed to emphasize the reservations that Dr. Commoner had stated. The meat industry later complained that the publicity raised needless public fears for the research was tentative and incomplete. Neither the complaint nor this fact has been widely publicized. Dr. Commoner is a skilled advocate of "public interest" science. I can't believe he didn't know what he was doing in promoting this study through the press. I am equally sure that he did it because he believes the public should be alerted to a possible danger. However, I would call it needless sensationalism.

Anonymous Warriors

A new and powerful element has entered the public arena in this decade. Advocacy science has become institutionalized in public interest groups. They range from locally based units such as the Union of Concerned Scientists in Cambridge, Mass., to national networks such as the organized opponents of nuclear power and multipurpose entities as the Nader-raider brigades. They can be as tough and Machivellian as an oil industry lobbyist, and as single-minded in crusading as Cromwell. They work with a sense of public purpose, although often it is marred by a zealot's self-righteousness.



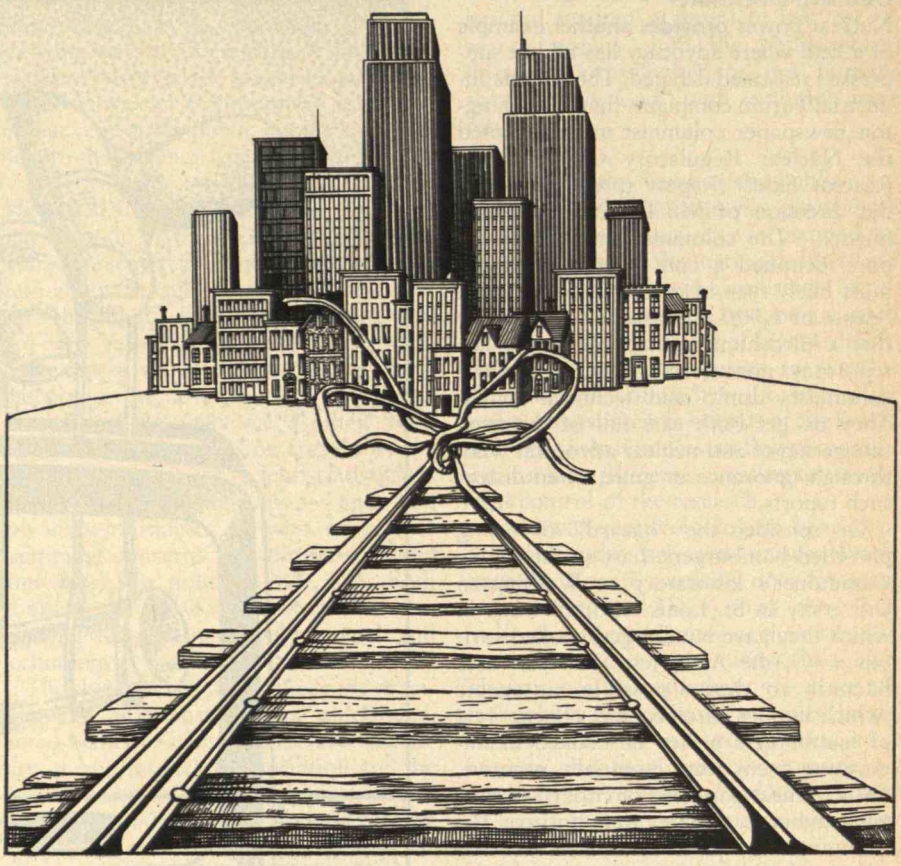
Mark Fisher

No matter how meticulously scientists word their warnings and analyses, these often will be subject to distortion if they are caught up in issues these advocates pursue. What can scientists do under these circumstances? Dr. John D. Holmfeld, a member of the House Committee on Science and Technology, says one of the best actions is to take part in the political process by talking directly to Congress. Too often, he says, it's the same faces showing up for hearings on science-related legislation. Also, the doors of senators and congressmen and congresswomen are open, as are the doors of their staff. They are busy, but will generally make time to discuss science-related issues with knowledgeable experts. They welcome views of those who aren't on the lobbying-advocacy trail. This quiet, publicly anonymous, action can be effective in countering misconceptions.

Other than that, perhaps it would help for scientists who have stood aloof from public interest groups to join a responsible organization if there is an issue of common concern. Then they can restrain the rhetoric and keep advocacy within the bounds of legitimate scientific inference. One thing scientists need not do is worry about their "public image." They seem to be doing all right on that score. □

Restrictions Derail the Nuclear Express

David F. Salisbury who reports on science for the Christian Science Monitor *from its West Coast Bureau, is a regular contributor to the* Review. *He studied physics at the University of Washington (B.S. 1969).*



Casserine Toussaint

A more immediate threat to the nuclear industry than the Clamshell Alliance's battle to stop construction of New Hampshire's Seabrook nuclear reactor or even President Carter's ban on the reprocessing of spent nuclear fuel may break the last link to its future.

Experts who spoke at the International Symposium on the Packaging and Transportation of Radioactive Materials held in Las Vegas in May gave an isolated picture for the outposts of the peaceful atom. "Transportation is rapidly becoming a major limiting factor in both current operations and in the maintenance of the nuclear option," warned Manning Muntzing, a lawyer who formerly was director of the Atomic Energy Commission's (A.E.C.) regulatory division.

Radioactive materials have been shipped around the country for 25 years with a record for human safety. Credit goes to the A.E.C. and the industry: their elaborate procedures for packaging and handling has assured protection from the diverse radioactive materials. About 2 million annual shipments — from drugs to radioactive wastes, from safe-to-handle low activity materials to those which would kill within seconds without protective shielding — were, until recently, made with relative routineness.

Although only a small percentage of these pertain directly to nuclear power, about 200 vital shipments of radioactive material must reach each nuclear reactor annually, says Robert Jefferson of Sandia Laboratories, chairman of the symposium. Commercial reactors cannot operate for longer than six months without refueling.

Nuclear's "Soft Underbelly"

Within the last few years these materials have become too "hot" to handle. Antinuclear forces have flagged the weak spot in the nuclear industry's well-riddled armor, according to Richard Pollack, director of Critical Mass, who has called transportation the "soft underbelly" of the industry. Carriers have shown increasing reluctance to handle readioactive materials. State and municipal governments have begun restricting the movement of radioactive wastes within their boundaries.

Congress first opened the wound in 1975 when plutonium was banned from air transport until the Nuclear Regulatory Commission (N.R.C.) could certify that a "safe container has been developed and tested which will not rupture under crash and blast-testing equivalent to the crash and explosion of a high-flying aircraft." A properly crash-resistant container will be ready this year for approval, after a three-year effort by the Energy Research and Development Administration, now the Department of Energy.

But the airlines are still reluctant to carry plutonium and the Air Line Pilots Association wants to ban all radioactive materials on passenger filights.

Now the railroads, the established carriers of radioactive materials, want to add their own requirements. Since the federal government first approached the railroads and solicited a price for handling radioactive materials, they have been accorded a rate lower than other hazardous materials. (Those in railroad circles know it as the "Jergen's Lotion rate" because hand lotion falls in the same rate schedule.) "We had no idea the traffic would become so great when we agreed on the price," says James Paschall of Chessie Systems Railroad with chagrin.

The railroads take a loss if they treat radioactive materials as they do other hazardous substances, says Mr. Paschall. For this reason and because of an intensified concern over the safety and liability involved with hauling the highly-radioactive spent reactor fuel, a number of railroads attempted to impose their own standards in 1976.

A Nuclear Express

They requested the use of special trains which travel at slow speeds, spend a minimum time in urban areas, and carry no other cargo. Because these actions would have more than doubled the freight rate, the nuclear industry balked. Backed by the Energy Research and Development Administration, they took the railroads to the Interstate Commerce Commission.

At the hearings, lawyers for the nuclear industry argued that the massive spent-fuel containers provided an adequate margin of safety to protect railroad work-

ers and the general public even in the event of a catastrophic train accident. They cited Sandia Laboratories' experiments ramming a truck carrying a waste-fuel cannister by a diesel locomotive traveling at 82 mph. In fact, they even calculated that the cancer-causing emissions of the diesel exhaust from extra locomotives would outweigh the diminished cancer risk from the reduced probability of radioactive accidents.

The railroads rejected the claims of the Sandia experiments outright. Because the cask was thrown up into the air, not run over, it was not a very stringent test, they argued. In addition, they faulted the government probability estimates of the radioactive-waste-carrying car being torched for being unrealistically low. Such fires can melt the lead shielding of the casks, and cause internal pressures high enough to blow a relief valve and release radioactively contaminated cooling water.

In all three cases brought before him, the I.C.C. administrative judge sided with industry. He ruled that the increment of additional safety which special trains would provide would not warrant the extra cost. The railroads have appealed all the cases to the Commission, which at this time has ruled on two. In those cases, the I.C.C. decided that the safety issue was outside its jurisdiction: the railroads must abide by the standards set by the Department of Transportation and the Nuclear Regulatory Commission.

The nuclear industry considers this a victory. But the railroads are indefatigable. "We agree with them that this material can be moved safely as long as it's moved in special trains," says Mr. Paschall. "It certainly would help them if they could point out that every practical safety precaution is being taken." He believes that special trains — rented cars at about $3000 per day — could work to save the industry money. The transit time of the car factors in the overall cost, and special trains would cut down on this considerably, Mr. Paschall points out. But one shipment of spent fuel recently took 30 days, provoking charges that the railroads had deliberately dawdled to make a point: an allegation which the railroads deny.

Forbidden Squares

If this acrimonious debate were not enough, it is the precedent being set by a few state, county and municipal governments which threatens to put the final shackles on the industry.

Within the last year the Energy Facilities Council of Oregon has passed regulations to consider the "risk of injury to the public health and safety" arising from waste transportation before issuing site certificates to nuclear reactors. In 1976 Connecticut passed a law which regulates the transportation of radioactive materials shipped within or through the state to nuclear facilities or waste disposal sites. "At the very least, we are beginning to see a checkerboard pattern emerge which contains certain squares through which no carrier of radioactive materials may go," warns Mr. Muntzing. If these forbidden squares continue to multiply, it will be impossible to maintain even the currently operating nuclear generating stations.

The Brookhaven National Laboratory on Long Island has already felt the cramp of this trend. At one time B.N.L. trucked wastes from its experimental reactor to New York City where they were shipped to the government facility at Savannah River, S.C. But in 1976 the New York City Board of Health forbade the transport of radioactive materials within the city limits except "for the most compelling reasons involving urgent public policy or national security interests transcending public health and safety concerns."

Brookhaven had no recourse but to barge its wastes to New London, Conn., for reshipment. But New London wasn't about to accept garbage New York had rejected. So now that city has imposed its own ban and it is unclear where Brookhaven will turn next.

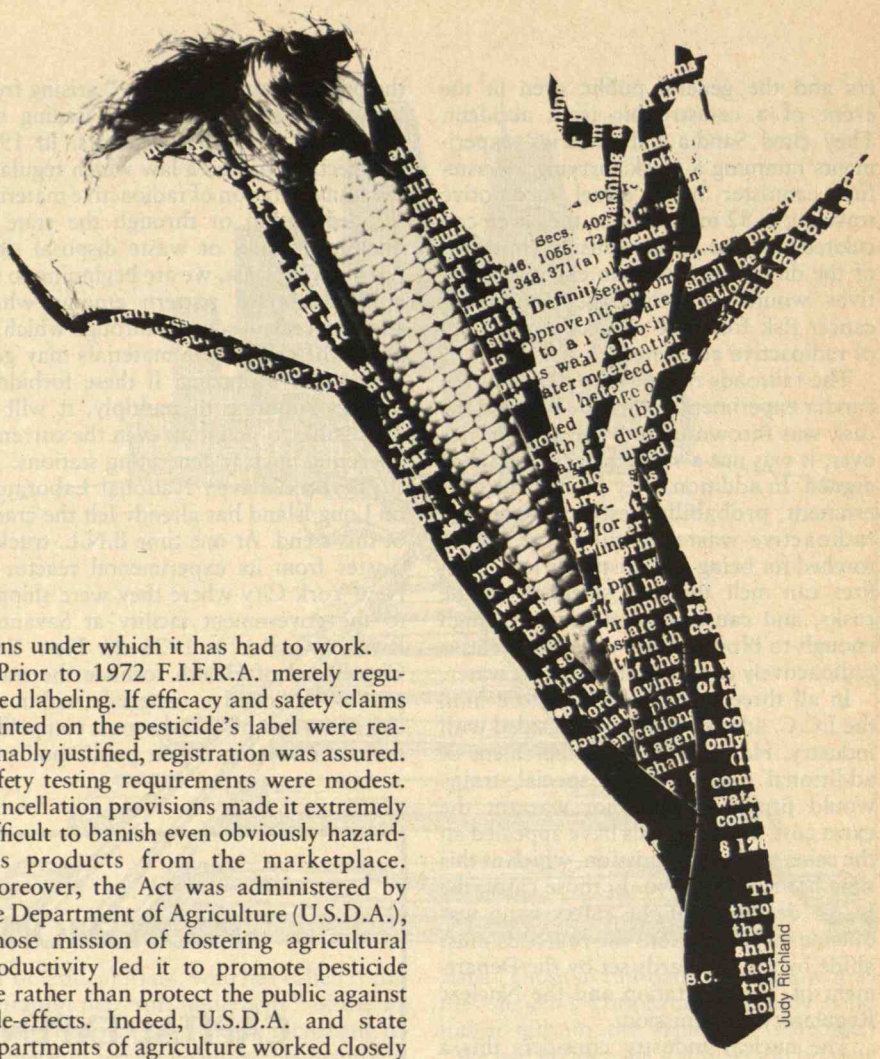
Suffolk County, N.Y., and Cincinnati, Ohio, are considering similar measures. In Chicago, on the other hand, an attempt to institute such a ban was defeated. But then Chicago depends on nuclear energy for 50 per cent of its electricity, more than any other U.S. city.

To the perturbation of the nuclear industry which argues that federal standards clearly pre-empt those of states and local governments, the Department of Transportation has sanctioned this trend by upholding the New York City measure. Without concerted federal action, transportation problems could very well hamstring commercial nuclear power, observed Robert Jefferson gloomily. □

Ian C. T. Nisbet

A Poor Harvest for Pesticide Regulation

Ian C. T. Nisbet, who writes regularly for Technology Review, *is Director of the Scientific Staff of the Massachusetts Audubon Society. His Ph.D. in Physics is from Cambridge University.*



The evaluation of hazardous pesticides already on the market and the registration of new products have been almost non-existent since the passage of major amendments to the Federal Insecticide, Fungicide, and Rodenticide Act (F.I.F.R.A.) in 1972. Action has been blocked by stringent guidelines for testing the safety of new pesticides, and by pressures from the "agro-industrial complex" against the re-registration of existing pesticides, which would eliminate the most hazardous chemicals and restrict the use of others to trained professionals.

After six years, F.I.F.R.A. stands as perhaps the most dramatic example of failure in federal environmental regulation. The 1972 amendments required review and re-registration of all existing pesticides within two years. Yet today, four years after the statutory deadline, not one of the 33,000 registered pesticides has met new approval. In 1969, a commission of the Department of Health, Education, and Welfare singled out 26 pesticides as health hazards and recommended an immediate check on their use. Nine years later, only nine of these hazardous pesticides have been restricted; only about half of the others are undergoing regulatory scrutiny. In 1972, the Environmental Protection Agency (E.P.A.) listed a further 100 pesticides as "suspect," giving them high priority for regulatory action. Of these, only a couple of dozen have been reviewed, and only a handful regulated.

Other reforms enumerated in the amendments — such as the setting of tolerances for pesticide residues in food, the classification of pesticides for restricted use, and the setting of field re-entry intervals to protect farm-workers — have been carried out dilatorily and ineffectively.

Senate and House oversight committees and the General Accounting Office have repeatedly criticized E.P.A. for its lack of response. However, before condemning E.P.A., one should be aware of the limitations under which it has had to work.

Prior to 1972 F.I.F.R.A. merely regulated labeling. If efficacy and safety claims printed on the pesticide's label were reasonably justified, registration was assured. Safety testing requirements were modest. Cancellation provisions made it extremely difficult to banish even obviously hazardous products from the marketplace. Moreover, the Act was administered by the Department of Agriculture (U.S.D.A.), whose mission of fostering agricultural productivity led it to promote pesticide use rather than protect the public against side-effects. Indeed, U.S.D.A. and state departments of agriculture worked closely with land-grant colleges and chemical companies to develop and test new pesticides, whose use was then promoted through an elaborate system of state agencies and county extension services. In this way pesticides acquired a central role in the agro-industrial complex. The political influence of this lobby still dominates congressional decisions on pesticide regulation.

During the 1960s, potential long-term health hazards posed by pesticides exploded into the public eye. U.S.D.A.'s disregard of this new knowledge was key in the establishment of E.P.A. in 1970. However, when E.P.A. gained the jurisdiction for pesticide regulation, existing laws, data files, and U.S.D.A. personnel were all transferred to it as well. As a result, the prevailing attitudes to pesticide regulation were not substantially changed. For more than six years, friction developed within the Agency as the courts ordered actions that were contrary to the philosophy of senior program officials.

The 1972 amendments to F.I.F.R.A. committed more fundamental changes than anyone realized at the time. In the first place, federal jurisdiction was extended to cover uses in addition to labelling of pesticides. This enormous burden of enforcement was loaded with safety and efficacy evaluations of each registered use. Secondly, much more rigorous reviews of risks and benefits were required. A pesticide could be denied registration if it was deemed to have "unreasonable adverse effects" on human health or the environment; yet the E.P.A. was also bound to consider the pesticide's social, environmental, and economic benefits.

Leaving aside the complexity of evaluating social, environmental, and economic benefits (which neither E.P.A. nor anyone else has been able to tackle), E.P.A. still has to evaluate a wide range of potential adverse effects in order to judge safety of each pesticide in each of its uses. Only extensive testing can demonstrate safety satisfactorily. To do this, E.P.A. has specified very detailed procedures for premarket testing of pesticides. To satisfy E.P.A.'s testing requirements for the regis-

tration of a new product now takes many years and the expenditure of millions of dollars. While few responsible persons would dispute the need for extensive safety testing of new products, there is now no economic incentive to develop the pesticides which are most urgently needed — selective chemicals with limited, specific uses and minimal side-effects.

Caught in a Political Stall

But the prescription of detailed testing requirements has not relieved E.P.A. from difficulties of scientific judgment. Each petition for registration and its voluminous file of supporting data, most of which requires expert evaluation, inevitably includes safety tests with inconclusive or equivocal results. Under pressure from Congress not to register products that might later prove hazardous, E.P.A. often avoids difficult decisions by asking for additional data. As a result the process of registering new products has been all but paralyzed for several years. In fact, only two new chemicals have been given the go-ahead in the past year.

This burden of proof has favored existing pesticides. Only a handful of those on the market have been given the scrutiny required by E.P.A.'s current regulations; most would be rejected summarily if they were judged by the strict standards applied to new chemicals. To make matters worse, E.P.A. files on the older chemicals are in disarray. And when the results of older tests have been dusted off, few meet modern scientific standards. Indeed, there is disquieting evidence that many of the tests were performed inadequately, incompetently, or even fraudulently. And every time E.P.A. acts against a suspect pesticide, the wrath of the agro-industrial community descends upon key congressional leaders, who lose no time in conveying their displeasure to the Agency. Thus E.P.A. is always under pressure to postpone decisions.

The irony of the 1972 Act has been the delay by at least five years of its intent: that hazardous pesticides already in use could be replaced by less hazardous new ones.

Political pressure has also impoverished other sections of the Act. The classification of certain hazardous pesticides for use only by trained professionals was originally viewed as an important regulatory tool. However, E.P.A. proposals for classification have been whittled down until the final regulation (years late) listed only a meager 17 pesticides. The requirements for "training" pesticide users were undermined by the specification by Congress that farmers did not need training. E.P.A. proposals for re-entry standards to protect field workers were similarly weakened, to cover only a dozen pesticides, and still permitted exposures known to be extremely hazardous. A proposed system for collecting and reporting incidents of pesticide poisonings was withdrawn by an E.P.A. under pressure.

Although some of the delays and inadequacies of pesticide regulation stem from bureaucratic inaction, scientific incompetence, or regulatory irresponsibility, the heart of the problem is political. The Agency constantly receives contradictory messages: the Congressional oversight committees take it to task for inaction or for taking short cuts, but every time it verges on decisive regulatory action, agro-industrial supporters in the Congress resist effective implementation of the Act.

The resolution of these problems is unclear. Perhaps in the long run, more efficient systems of integrated pest management could eliminate much pesticide usage. However, such reform is against the interest of the agro-industrial complex, which is now effectively delaying such action. In the short run, even if E.P.A. could be revamped bureaucratically and scientifically, there are far too many pesticides on the market. In any case, many decades will pass before they are all tested and evaluated in the detail required to ensure safety.

I submit that a good quarter of the pesticides currently registered will be found to cause "unreasonable adverse effects," and half the rest will be found to provide negligible benefits. It seems particularly unreasonable that inadequately tested old pesticides now enjoy a regulatory advantage over well-tested new ones. The only solution is to shift the burden for completing testing and for shaking out the most hazardous chemicals back to industry. An imaginative scheme would be to grant provisional re-registration to all existing products and impose an economic penalty (a tax) on all products which have not been tested fully. However, to introduce such a scheme would require a major change in the law, and the prospects for this are bleak in the present political climate. □

The Ethic of Science and the E.R.A.

Kenneth E. Boulding is President-elect of the American Association for the Advancement of Science, Distinguished Professor of Economics at the University of Colorado at Boulder, and a director of the Institute of Behavioral Science. He writes regularly for the Review.

A considerable number of professional and scientific associations have been trying to put pressure on state legislatures who so far refuse to ratify the Equal Rights Amendment by refusing to hold their conventions in these states. Not only has this involved a long-range boycott of non-E.R.A. states, but in some cases there has been a cancellation of previous plans and a shift in the location of meetings. Thus, the Board of the American Association for the Advancement of Science, meeting in Washington in February, decided to move its annual meeting planned for January, 1979, from Chicago to Houston, mainly because the state of Illinois had not ratified the E.R.A.; thus the A.A.A.S. would demonstrate its support for women as an underprivileged minority and avoid the demonstrations and disruptions which were feared if the convention were held in Chicago.

The implications of these actions, especially for the scientific community, are a matter of serious concern. They involve the advocacy of the secondary boycott, that is, being nasty to somebody in the hope they will be nasty to somebody else, in the further hope that the opinion or actions of that second party will be changed. The efficacy of secondary boycotts is extremely dubious. I do not know of any well-authenticated case where they have been successful; I am sure some may exist and research on this problem is very much in order. It would certainly be rash to say that such boycotts can never be effective and can never be justified, but the grave doubt about their effectiveness means that any particular case should be scrutinized with the utmost care.

In the case of E.R.A. boycotts, it seems to me this scrutiny has not been made and very little attempt has been made to draw up an overall cost-benefit analysis. The costs, however, seem to be very high and the benefits very dubious. The principal costs are a destruction of trust, a commodity which is becoming alarmingly scarce and is of correspondingly high value, and an erosion of the ethic of science itself. The benefits in this case, it is hoped, will be the establishment of rights long denied women by a male-oriented American society.

In my judgment, the benefits seem highly dubious. In the first place, there is considerable doubt as to whether such boycotts of non-E.R.A. states will in fact affect the votes favorably in their legislatures. The situation is particularly ironic in regard to Illinois, where it is mainly the suburban and downstate legislators who have prevented passage of the E.R.A. Here those who boycott Chicago seem to be penalizing friends rather than enemies, which is a very strange way to influence people.

The Uncertain Benefits of E.R.A.

Then one has to raise questions about whether the Equal Rights Amendment itself will accomplish its objectives. I regard myself as a strong supporter of equal status for men and women. I was an active member of the committee of the American Economic Association on the Status of Women in the Profession for its first three years. I have consistently advocated that discrimination against women is a shocking waste of resources, as well as an injustice, which we can ill afford. I am against the arbitrary allocation of social and economic roles on the basis of sex, and I think that the status of women historically is one of the great tragedies of the human race which is by no means over. If I thought that the passage of the Equal Rights Amendment would solve this problem once and for all, I would be prepared to pay a high cost in order to do this. However, I have grave doubts.

The genetic differences between men and women are large. Equality is not the same as identity. Differences do not imply either superiority or inferiority, domination or submission. In the face of such very complex differences, equality of status has to be worked out by a very complex process involving love and affection, respect and benevolence, as well as bargaining, contracts, and legal rights. The concept of rights is an empty one in the absence of the specification of duties, for the right of one person must always be interpreted in terms of the duties of another. Trying to specify rights without specifying duties is likely to be empty and may even discourage the duties which we are trying to encourage.

If I had to vote on the Equal Rights Amendment I am pretty sure I would vote for it, if only for the objectives which it symbolizes. I would, however, have grave doubts as to whether it would accomplish these objectives. I strongly suspect that most of the opposition to the Equal Rights Amendment comes from motives of which I do not approve. But in the light of the enormous complexity of social systems, and the strong probability of unexpected results from almost any intervention into them, honest doubt as to its effects if the E.R.A. were to be passed seems to me entirely legitimate. And in the light of these uncertain benefits, the costs of action in support of the Equal Rights Amendment should, I think, be low.

The High Costs of a Boycott

In contrast, the costs of the boycott action by the professional and scientific associations seem to me to be very high. The professional associations are accustomed to conduct arrangements with hotels on an informal basis, ratified by a simple handshake. These handshakes are now increasingly worthless, and that is a high cost. Behind any legal framework there is an ethical matrix — of trust, confidence, fulfillment of promises, and so on — which may not have legal sanctions, but in the absence of which even the legal sanctions themselves may turn out to be impotent. The destruction of trust in any form is chipping away at the cement which holds society together.

It is essential to the ethic of science that people should be persuaded by evidence and not by threats. The attempt to force passage of the Equal Rights Amendment not by research, not by evidence as to its benefits, but by threats to parties who may then threaten others (a technique, as I have already said, of dubious efficacy) seems to me totally inconsistent with the ethic of the scientific community. Science has advanced human knowledge so spectacularly precisely because it abandoned threat as a means of changing people's opinions. An inquisition in the scientific community would be utterly inconsistent with its ethic and would destroy it. It is the business of the scientific community not to produce truth, or even agreements, but to present evidence, obtained by asking intelligent questions of the real world and waiting in patience and humility for the reply.

It may be argued against this position that what we are dealing with here is the realm of values not the realm of fact, that opposition to the Equal Rights Amendment is a result of evil values and that the only answer to evil values is threat. I

would not argue that threat is always illegitimate; indeed, political systems would be impossible without legitimated threats. That there might be occasions in which the scientific community would have to resort to whatever threat power it might have in order to prevent a dangerously adverse social change or in order to counter a threat to the scientific community itself is certainly a reasonable proposition. On the other hand, to assume that values can only be changed by threat, or even that this is the best way of changing values, is a hypothesis that needs scientific testing and could well turn out to be usually wrong.

The use of threat without any attempt at persuasion, argument, or the presentation of evidence, which the professional and scientific associations seem to be doing in regard to the Equal Rights Amendment, seems to me utterly foreign to the whole spirit and ethic of the scientific enterprise and can hardly fail to do harm not only to the scientific community itself but to the very objectives which it is intended to foster. Those proponents of the Equal Rights Amendment who have persuaded the scientific and professional associations to take this step may have won a battle; but the cost may be so high they may lose the war. The deep anger which has led to the E.R.A. movement is just, in the sense that there is something to be angry about. But anger, while it promotes activity, corrupts judgment; and what is just is not always wise. I hope my many friends who will be angry with me for this essay will recognize this, and forgive me. □

Solar Cells: Plugging into the Sun

Solar cells convert sunlight into electricity silently and without pollution. New materials and new fabrication techniques may bring down their costs significantly.

John C. C. Fan

A solar cell is a semiconductor device that converts sunlight directly into electricity — a very useful and versatile form of energy. Solar cells, also called solar photovoltaic cells, promise an enormous number of uses because of the many advantages they have over other power systems:

- ☐ Photovoltaic cells capture sunlight, an essentially inexhaustible source, converting it directly into electricity.
- ☐ Photovoltaic conversion of sunlight to electricity requires no heat engines and produces no noise, no waste, and no pollution.
- ☐ Photovoltaic systems are modular, permitting a variety of applications.
- ☐ Photovoltaic systems could be reliable and durable, requiring little maintenance.
- ☐ Solar cells function wherever sunlight is available, making them particularly attractive in remote areas where power lines cannot be readily or cheaply routed.

Terrestrial Solar Cells

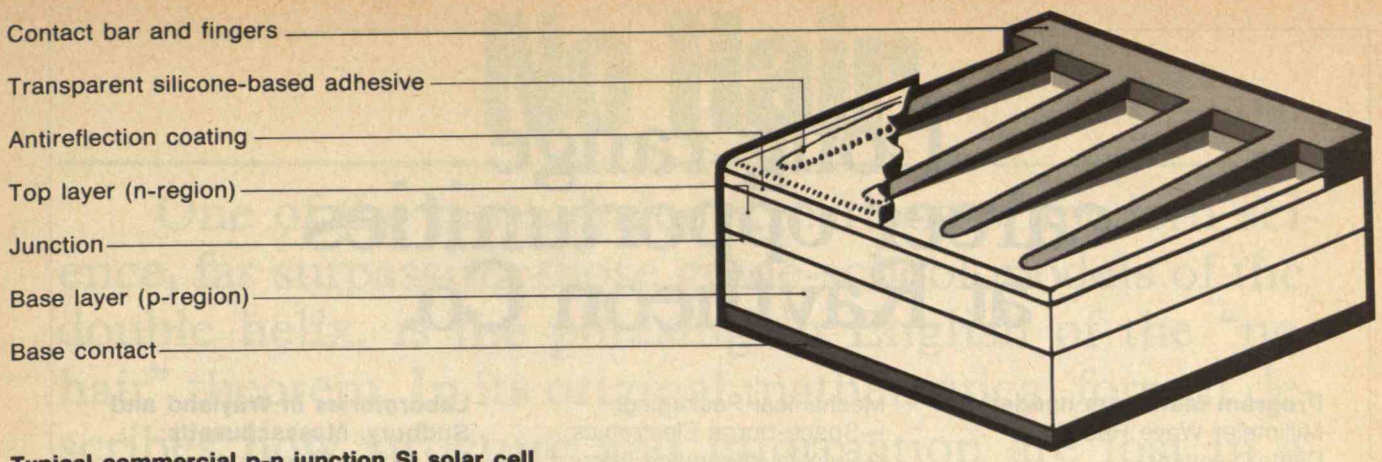
In space, where their high power-to-weight ratio and reliability are especially desirable characteristics, solar cells have been used extensively and successfully. On earth, where power systems must provide large amounts of electricity at reasonable costs, three major limitations have thus far impeded the widespread use of today's relatively costly solar cells: solar cells are expensive; sunlight has a comparatively low energy density; and, the best solar cells convert sunlight to electricity with limited efficiency. Clearly, terrestrial solar cells must be as efficient and as cheap as possible.

The power density of sunlight is only about 1350 watts per square meter just above the earth's atmosphere (conditions described as air mass zero, or AM0 — Air mass is a term that defines the effect on the solar spectrum of passing through varying depths, in miles, of atmosphere) and less than 1000 watts per square meter[1] on earth after filtering through the atmosphere. The best conversion efficiencies theoretically attainable from today's most promising cells range from 22 to 26 per cent at AM0, and actual cell performance falls short of even these limits. (The conversion efficiency of a solar cell is defined as the ratio of electrical power output to solar power input.) Because of the low power density of sunlight and the limited conversion efficiencies, today's best solar cells can generate only about 250 watts per square meter. Great areas of efficient — and inexpensive — solar cells certainly will be needed to provide large amounts of electrical power. For most practical applications solar cells must have conversion efficiencies of 10 per cent or higher or collection areas could become overly enormous; prices of solar cells will be based on their power output capability.

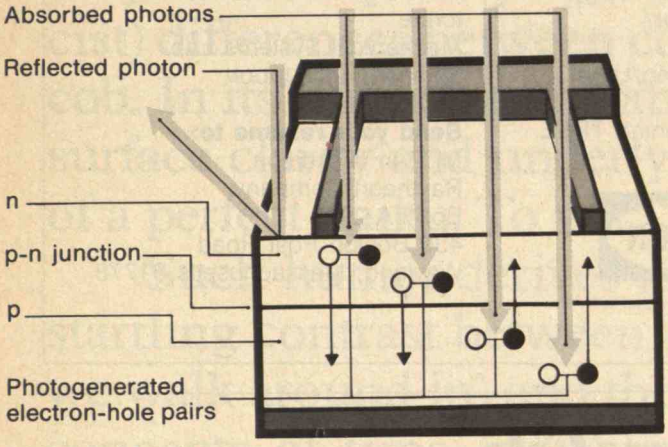
Although solar cell prices have fallen, they still have a long way to go. The price of a silicon solar cell module — an interconnected group of silicon solar cells — recently fell to $11 per peak watt, equivalent to $9.50 in 1975 dollars.[2] That is, it costs $9.50 in 1975 dollars to purchase a solar module that will produce one watt of power under AM1 illumination. The Department of Energy (D.O.E.) has set a 1986 price goal of only 50 cents for solar modules that can produce a peak watt and a 1990 goal of 10 to 30 cents, all in 1975 dollars.[3] If modules become this inexpensive, electricity produced by solar photovoltaic conversion systems may be competitive with electricity sold at bulk rates to large industrial consumers.[4]

It is projected that by the year 2000 the U.S. could have installed photovoltaic conversion systems with a production capacity of about 5 billion watts of electricity[3] — roughly equivalent to fifty of today's very large generating plants. This capacity growth, though substantial, would be restrained by the huge capital costs and long lead time

These five diagrams illustrate the general configuration of present-day solar cells. They are intended for illustrative purposes only and are not drawn to scale.
Although the commercial solar cell (top) is portrayed to have a rectangular shape, cells are often shaped differently. For example, they can also be circular. Similarly, the pattern of fingers and bars, which collect the charge carriers from the top cell layer, can differ from that shown (see cover of this issue for one variant). Solar cells may have either a p-layer or an n-layer on top; strictly speaking, the cell depicted in the top diagram has an n-p configuration. (In the notation describing junction configuration, the doping characteristic of the top cell layer is sometimes listed first.)
The lightly shaded layers in the center right and lower two diagrams are where most photogenerated charge carriers are created. Such carriers must migrate to cell junctions in order to produce a photocurrent. This migration can occur only if the cell material is good enough to permit such movements. Major factors inhibiting such carrier migration are: impurities, defects, and grain boundaries in cell materials.
The thickness of the top, Cu_xS, layer in the conventional thin-film solar cell (bottom, left) is 0.2 to 0.4 micrometers, two orders of magnitude thinner than the bottom, CdS, layer. (A μm, or micrometer, is 10^{-6} meter.)
The advanced thin-film solar cell configuration (bottom, right) is presently under study at Lincoln Laboratory.



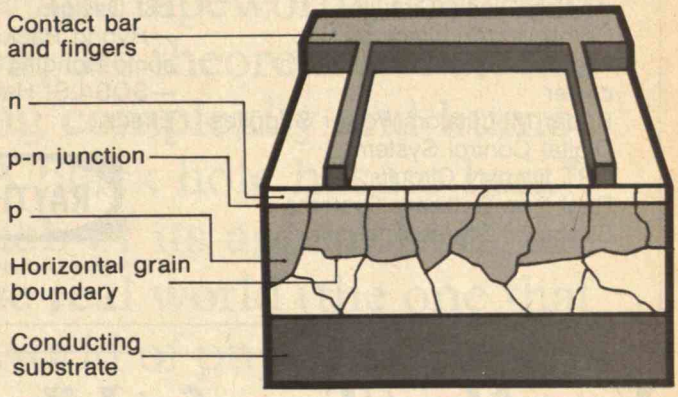
Typical commercial p-n junction Si solar cell



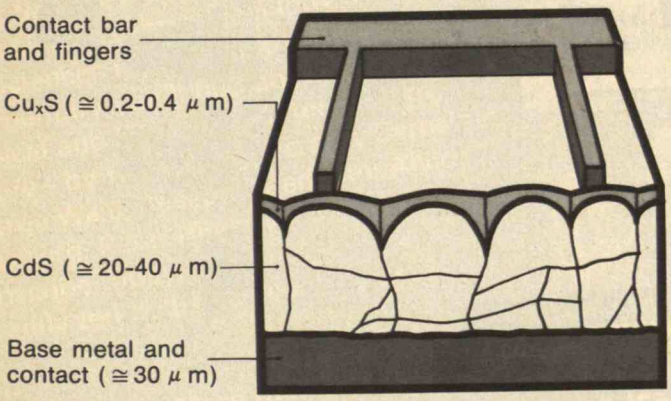
● Electron: negative charge carrier

○ Hole: positive charge carrier

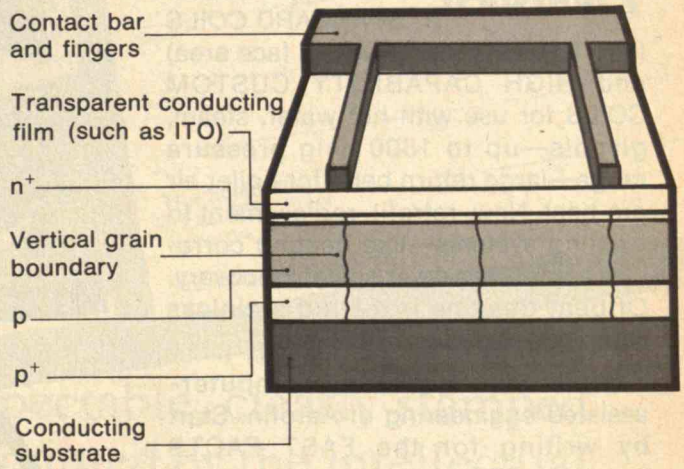
Photogeneration of charge carriers



Conventional thin-film homojunction solar cell



Conventional thin-film Cu_xS/CdS heterojunction solar cell



Advanced thin-film solar cell

No Hair

One of the transcendent creations of modern science, far surpassing those grade-school models of the double helix, is the phrasing in English of the "no-hair" theorem. In its original mathematical form it describes how structure and information are lost in a black hole, how the fundamental distinctions between baryon and lepton go the way of the trivial (to a physicist) differences between cow and tapeworm, corn and cob. In its English translation, the theorem has all the surface clarity and underlying complexity and humor of a perfect haiku. To wit: "A black hole has no hair."

Such humor derives much of its appeal from the startling contrast between the real world (the one that we walk around in) and the world of physicists, where concepts of time, causality, and baldness are all bizarrely twisted. When one realizes that physicists are not kidding, it is hard to avoid a kind of [illegible] particularly for those of [illegible] into a [illegible]

[illegible] toward [illegible] respectable, clearly stamped [illegible]'s imprimatur, untainted by the intellectual guilt that may accompany religious flirtation, it provides abundant evidence that the world is not what it seems, that things are, indeed, strange and wonderful.

needed to develop solar photovoltaic technology — and to build and install the necessary hardware.

Solar Photovoltaic Power Conversion Systems

Solar cells are only one part of complete solar photovoltaic power conversion systems. A solar photovoltaic system also contains array structures to support the modules, circuitry to control and modify the output in various ways, and if required, a means of storing energy.

The cost of the array structures that support the modules has been estimated to be a significant portion of photovoltaic system cost.[5] Ancillary circuitry may also be costly: the direct current (DC) produced by solar cells must be changed to the alternating current (AC) used by most electrical loads and utility systems.[6,7] For many applications, electrical storage is needed to provide electrical power when the array is not producing power[8], to supplement the array output during transient loading[9], or to aid in utility power system load leveling. In addition, a means of regulating the flow of power between the solar array, energy storage, and load is often required.[10,11]

Air mass	Depth of atmosphere	Solar power density (W/m²)
0	zero (in space)	1350
1	1 mile (≅ sea level; sun at zenith)	930
2	2 miles (≅ sea level; sun 60° from zenith)	750
3	3 miles (≅ sea level; sun 70.5° from zenith)	620

The air mass number is equal to the number of miles of atmosphere sunlight must penetrate before striking a solar cell. The conditions described in parentheses approximate these atmospheric depths. For comparison, at AM1 the sun's energy falling on 10 square meters of area (about the size of an average automobile) for a four-hour period is equivalent to that stored in a gallon of gasoline.

The figures in the second table describe D.O.E. price and production goals for solar cell modules — interconnected groups of cells mounted in a supporting panel or frame. (An array is a larger structure containing many modules.) The goals for 1990 call for more than an order of magnitude drop in the prices of modules and a many order of magnitude rise in production from today's levels. Note that the 1977 total production figure is for *world* production; all other production data pertain to U.S. output only. (Data: Reference 3)

	Module price (1975 $/peak W)	Total production	Estimated energy cost (¢/kWh incl. system costs)
1977	9.5 - 13	7.5×10^5	—
1982	2	2×10^7	10 - 20
1986	0.5	5×10^8	5 - 8
1990	0.1 - 0.3	—	4 - 6

To further the utilization of terrestrial photovoltaic systems, the D.O.E. has developed a Systems Test and Applications Plan emphasizing the following four objectives:[3]

- ☐ The establishment of the technical credibility of solar photovoltaic power systems;
- ☐ The identification and elimination of technical and institutional constraints to their widespread acceptance;
- ☐ The provision of data to permit the economic modeling of solar photovoltaic power systems;
- ☐ The reinforcement of overall national energy goals as indicated in the table to the left.

Photovoltaic systems are being used and evaluated in D.O.E. testing and demonstration projects in domestic agricultural, residential, commercial, military, and institutional applications.[12-16] They are also being tested for many applications in less developed countries.[17,18] These photovoltaic test and demonstration programs are expected to encourage the purchase of many solar cell modules, stimulate the market, support higher production capacity, and concomitantly encourage lower module — and system — prices. Just as important as their encouraging effect on price and supply, the D.O.E.-sponsored efforts will help accumulate experience and data on which analyses of different system applications can be based.

The production of electricity from sunlight with photovoltaic power systems promises wonderful benefits. But the key to their success is the improvement of solar cells themselves. The remainder of this article will explore the efforts being made to achieve the needed price reductions and also to increase the efficiency with which solar cells convert sunlight into electricity.

How They Work: Electrons, Holes, and Junctions

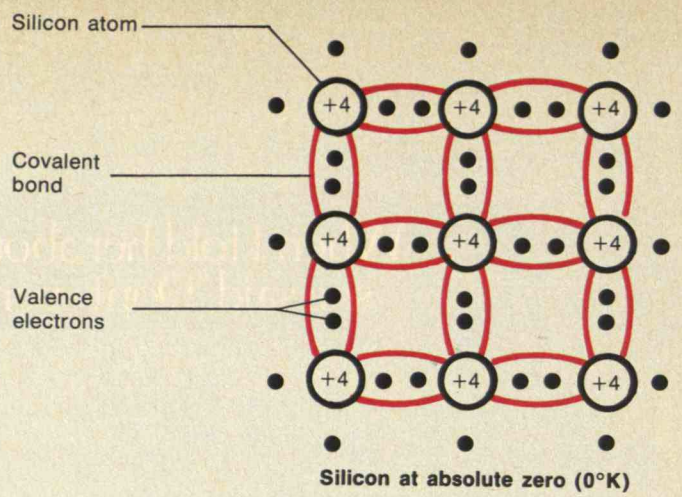
To better understand the various aspects of solar cell development, it is helpful to understand how they function. Crystalline silicon p-n junction solar cells, the only type commercially available at present, work in much the same manner as other types of cells that are being developed, and are offered as an illustrative model.

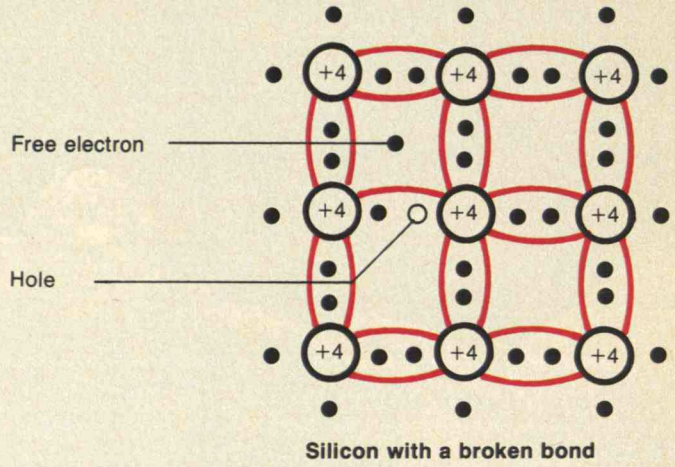
When sunlight falls on a silicon solar cell, a voltage is induced and an electric current flows in an external circuit connected to the cell. Since an electric current is a flow of electrons, and the source of this particular current is in the crystalline silicon, the bond structure and behavior of the electrons within the silicon crystal should be clearly

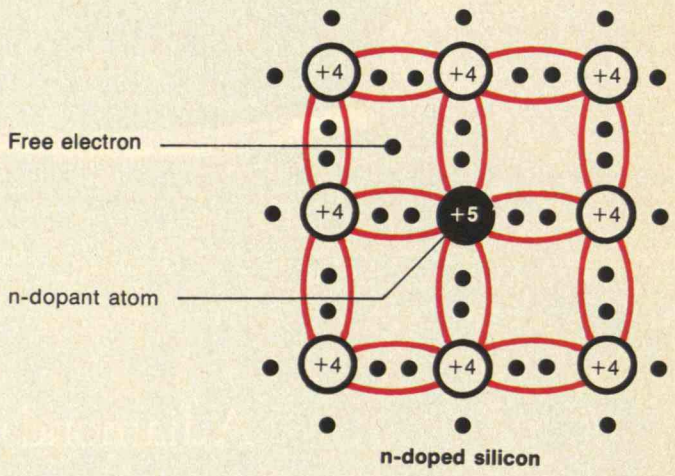
When I told her about my raise last night, she said, "Don't spend it all in one place."

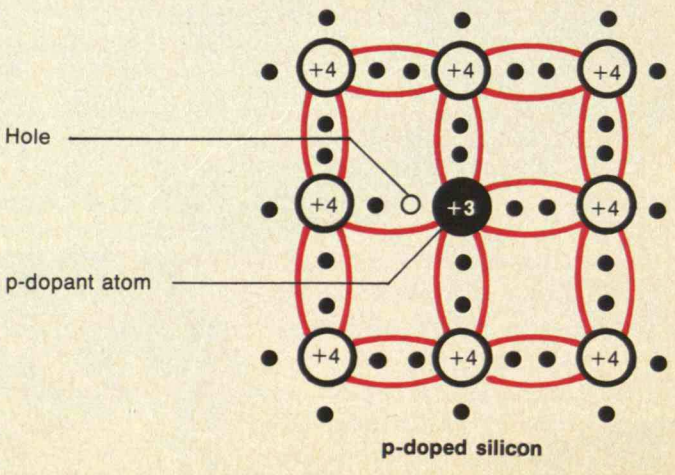
A diamond is forever.

To give you an idea of diamond values, the bracelet shown is available for about $4,200. Your jeweler can show you other diamond jewelry starting at about $300. De Beers.









The effects of breaking bonds and of adding dopants to the lattice, or structure, of a silicon crystal are shown in this series of two-dimensional representations.

The top drawing shows a silicon crystal lattice with no broken bonds and no dopant. Each silicon atom has four valence electrons that are held strongly in covalent bonds. The "+4" in the center of each atom indicates the four positive charges in the atomic nuclei that balance the charges of the four valence electrons.

The second diagram shows a silicon crystal lattice that contains a bond broken either by thermal or light energy. When a valence electron breaks away from a covalent bond, it "leaves behind" a hole, which behaves like a positive charge carrier.

The third diagram depicts the lattice of a silicon crystal made into an n-type crystal. For illustrative purposes, the replacement of only one silicon atom with an atom of n-type dopant — having more than four valence electrons — is shown. The donor dopant illustrated has five valence electrons, with five charges in its nucleus to balance these electrons. The fifth valence electron is usually not held in a covalent bond and is often called a "free" electron.

The bottom diagram shows the lattice of a p-type silicon crystal. The atom of an acceptor dopant with only three valence electrons has replaced a silicon atom, leaving a hole in the crystal lattice.

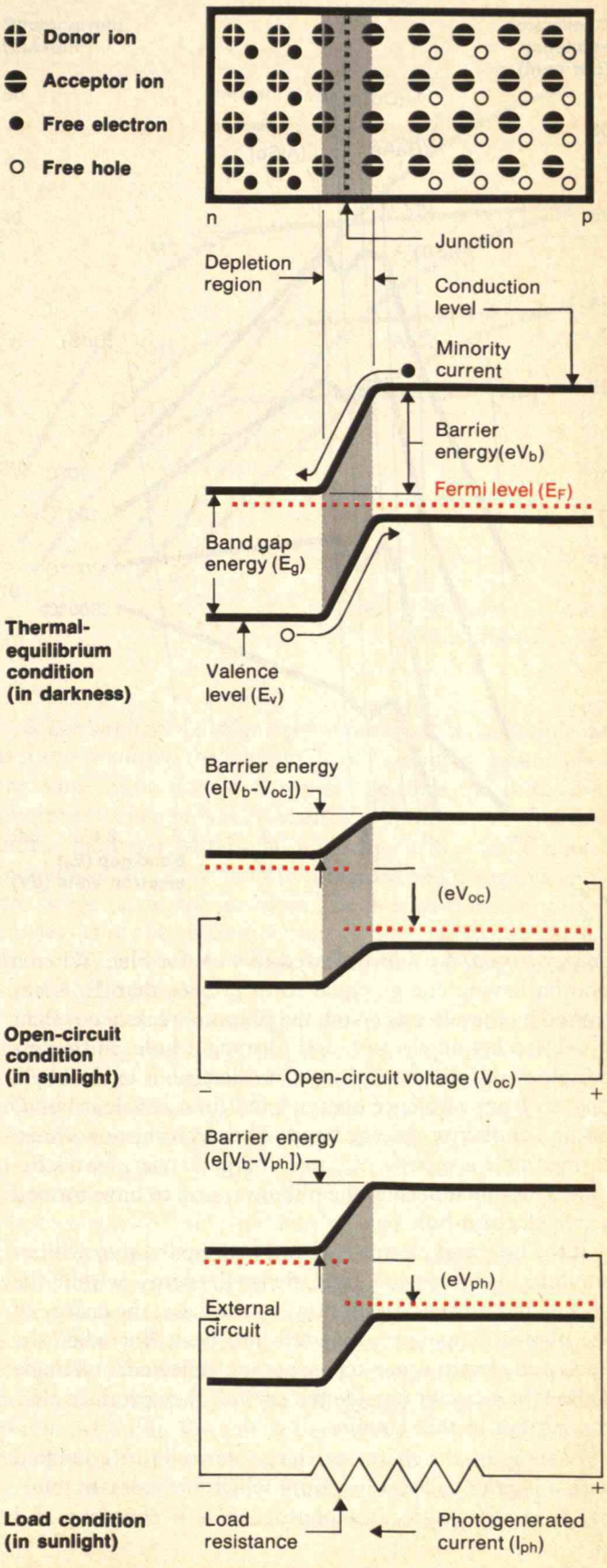
and thoroughly understood.

A silicon crystal consists of atoms arranged in a regular three-dimensional network called a crystal lattice. Each atom is surrounded by and bound to four equidistant neighboring atoms. The outermost electron orbit of silicon atoms contains four electrons, which are called valence electrons. Each of the four valence electrons of each silicon atom in the crystal lattice is shared by one of its four nearest neighbors. This electron-pair bond, called a covalent bond, binds the crystal firmly together. If all the valence electrons were inexorably bound, as they would be at absolute zero (0°K), the silicon crystal would be an insulator, since no free electrons would be available and conduction would thereby be precluded. But the covalent bonds can be broken — for example, by thermal excitation. The energy required to break a covalent bond is called the bond energy or energy gap, symbolically E_g. In silicon, E_g is about 1.1 electron volts (eV).

The absence of an electron from a covalent bond is called a hole. A neighboring valence electron may now leave its covalent bond to fill this hole, creating a hole in a new location. The new hole can in turn be filled by a valence electron from another covalent bond, and so on. Hence, a mechanism is established for electrical conduction that involves the motion of valence electrons and that does not involve any free electrons. Thus, although a hole is actually an artifact, it can be used as a real physical entity, to keep track of the motion of the valence electrons. Because holes and electrons move in opposite directions

under the influence of an electric field, a hole is considered to have the same magnitude of charge as an electron, but is opposite in sign.

The energy in light also can break the bonds holding silicon valence electrons. Light can be considered to consist of many packets of energy called photons. (Each photon has energy equal to the product of Planck's constant and the frequency of the light, stated symbolically as $E = h\nu$, where E is photon energy, h is Planck's constant, and ν is the frequency of the light.) Solar photons range in



The upper diagram illustrates symbolically the distribution of charges in an n-p junction solar cell. In the region away from the junction, donor and acceptor ions are neutralized by the presence of free charge carriers. (Donor ions, donated by circled + signs, are dopant atoms that have contributed electrons to the crystal lattice, and thus have positive net nuclear charges. Similarly, acceptor ions, denoted by circled − signs, are dopant atoms that have contributed holes to the crystal lattice and have net negative nuclear charges.) The region immediately next to the junction is depleted of free charge carriers needed to electrostatically neutralize these ions, and is commonly known as the depletion region. These unneutralized ions produce an electrostatic voltage V_b across the junction.

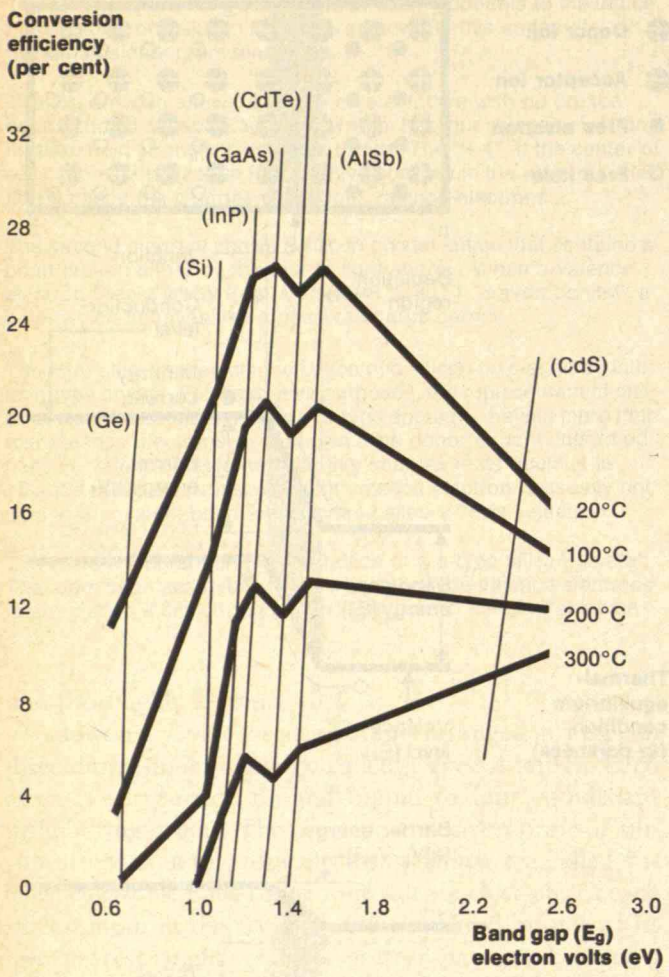
The lower three drawings are simplified energy band diagrams of the same cell. Such diagrams are used to illustrate principal junction characteristics under various operating conditions. The uppermost curved line in these denotes the conduction energy level E_C for the electrons in a solar cell; the lowermost curved line denotes the valence energy level E_V for the electrons. The cell's band gap energy E_g is represented as the distance between the E_C and E_V lines. The dotted line indicates "Fermi level," the level of energy at which the probability of occupancy of an electron state is 50 per cent. Below this level more than 50 per cent of the available electron states will be occupied. The relative position of the Fermi levels across the junction indicates the presence or absence of induced voltage. When the Fermi levels are lined up (as in the first energy band diagram), there is no induced voltage; when they are offset (as in the two lower diagrams), the magnitude of the offset indicates the magnitude of the induced voltage.

Under thermal equilibrium and in darkness (first energy band diagram), the Fermi levels line up and the barrier energy of a solar cell is at its maximum value of eV_b. Note that V_b is the built-in barrier *voltage* and eV_b is barrier *energy*, where e is the magnitude of charge carried by an electron (or hole). In general, the magnitude of eV_b is close to but always less than the band gap energy E_g; the larger the band gap is, the greater will be V_b.

When a circuit containing a resistance load connects the p-region and n-region of a solar cell in sunlight (third energy band diagram), the Fermi levels are offset by the photogenerated voltage V_{ph}, and the barrier potential becomes $(V_b - V_{ph})$. Note that V_{ph} is always less than V_{oc}, and that both V_{ph} and V_{oc} are reductions in the solar cell's barrier potential from V_b.

Under open-circuit conditions (no external circuit) and in sunlight (second energy band diagram), the Fermi levels are offset across the junction, indicating the existence of a net induced voltage across the junction. This voltage, called the open-circuit voltage V_{oc}, reduced the barrier potential at the junction from V_b to $(V_b - V_{oc})$.

This chart is based on calculations of the conversion efficiencies of p-n junction solar cells made of various materials. For cells using other kinds of junctions, the largest losses still depend on the energy gaps of the semiconductor materials used. The maximum calculated efficiencies of Schottky and MIS cells depend on the band gap energies of their host semiconductors. The maximum calculated efficiency of a heterojunction depends primarily on the energy gap of the semiconductor layer that absorbs the bulk of the solar photons. (Data: Reference 21)



energy from 0.5 eV for infrared to 4 eV for blue. When a photon having energy equal to or greater than E_g is absorbed by the silicon crystal, the photon breaks a covalent bond, freeing an electron and forming a hole. In the terminology of solid state physics, an electron is excited by a photon from a valence energy band (in a covalent bond) into a conduction energy band. The electron, now transformed into a mobile negative charge carrier, leaves behind a mobile hole, and the photon is said to have formed a free electron-hole pair.

If the hole and electron are not kept apart, they will recombine, producing a little thermal energy within the crystal and no net current flow. In this case, the energy of the photon is merely converted into heat. But when the holes and electrons are kept separate, collected, and made to flow in a circuit outside the crystal, they produce electric current in that circuit.

To separate the charge carriers, solar cells are equipped with a barrier called a junction, which provides an internal field that segregates photogenerated electrons and holes. Thus, while unmodified silicon has an equal number of holes and electrons, a p-n junction silicon solar cell consists of two charge-dissimilar regions separated by a junction: one region is rich in holes (p-type silicon); the other, rich in electrons (n-type silicon).

Such regions do not occur naturally. They are manufactured by replacing some silicon atoms in the lattice with atoms having a valence other than four, a process called "doping." In practice, replacing a small number of silicon atoms, on the order of one in millions, causes large increases in the electrical conductivity of the resultant doped crystal.

Atoms of elements that have a valence greater than four (such as phosphorus or arsenic, which have a valence of five) are one type of "dopant." These high-valence dopants contribute free electrons to the crystal and are called donor dopants. When in the lattice, four of the five valence electrons of these donor dopants are held by covalent bonds, but the fifth electron is very weakly bound, detachable by only about 0.03 eV of energy, and is then available as a free electron — a carrier of electrical charge and current. In this manner, a silicon crystal with added donor dopants has excess electron carriers, and is called n-type (negative) silicon.

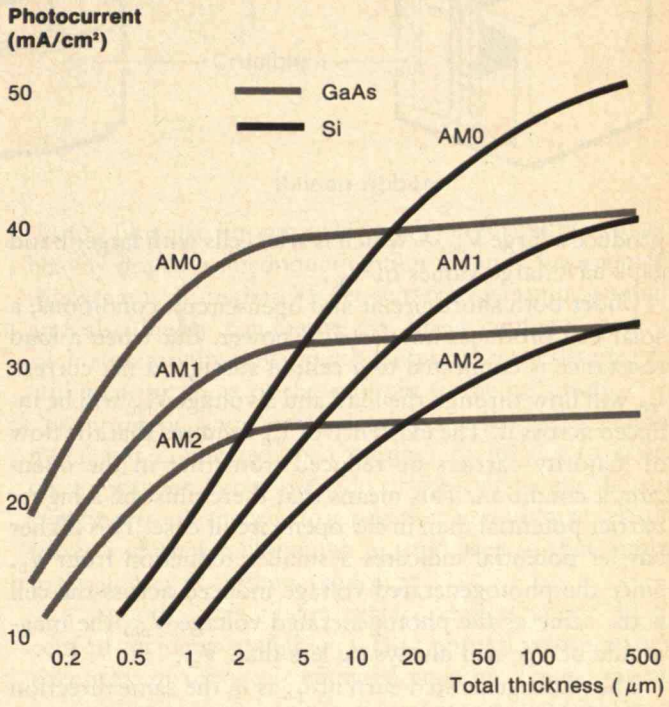
When a silicon crystal is doped with atoms of elements having a valence less than four (such as boron or gallium, which have a valence of three), only three of the four covalent bonds of some silicon atoms are occupied. The vacancy that exists at an unoccupied covalent bond constitutes a hole. Dopants that contribute holes, which act like positive charge carriers, are called acceptor dopants. The resulting crystal is called p-type (positive) silicon.

Conductivity in doped silicon crystals is determined by the properties of the added charge carriers, which are called majority carriers. In n-type silicon electrons are majority carriers and holes are minority carriers. It can be seen readily that there are fewer holes in n-type silicon than in undoped silicon because the large number of electrons causes some recombination with preexisting holes. In p-type silicon holes are the majority carriers and electrons are the minority carriers. Fewer electrons are present in p-type silicon than in undoped silicon because of the recombination of some electrons with the enhanced population of holes.

Action at the P-N Junction

Imagine bringing into intimate contact two pieces of silicon, one n-type and the other p-type. Initially there are nominally only electron carriers on the n-side of the newly formed junction and hole carriers on the p-side. This condition causes a large difference in electrostatic charge density across the junction. Immediately electrons

This graph shows the maximum photocurrent computed for silicon and gallium arsenide solar cells as a function of cell thickness for AM0, AM1, and AM2. Notice that a gallium arsenide solar cell two micrometers (μm) thick can produce its maximum photocurrent, while a cell made of silicon must be several hundred micrometers in thickness to produce its maximum photocurrent. A milliampere, or mA, is a unit of electrical current equal to 1/1000 of an ampere. (Data: Reference 51)



and holes diffuse across the junction in opposite directions. The redistributed charge carriers recombine and form a "depletion region" devoid of free charge carriers in the neighborhood of the junction. The width of the depletion region varies with the concentration of the dopants, but generally is less than 10^{-4} centimeters.

In the depletion region, the unneutralized donor and acceptor atoms (unneutralized because they have lost their respective free electrons and holes) produce an electric field. This field causes an electrostatic potential, or barrier potential, V_b across the junction. V_b is a measure of this electrostatic potential, which acts to keep majority carriers on their respective sides of the junction.

In the normal operating temperature ranges for solar cells, almost all the extra valence electrons associated with the donor dopant atoms in the n-region escape their weak bonds and reach the conduction band, becoming free carriers. In the p-region the holes associated with the acceptor dopant atoms are also "free" but are in the valence band.

The free electrons are the majority carriers in the n-region; the holes, in the p-region. The number of majority carriers, in general, is determined by dopant concentrations and not very sensitive to either thermal or light excitation. But the number of *minority carriers* — holes in the n-region and electrons in the p-region — is very sensitive to both thermal and light excitation, and this sensitivity has profound effects on the operation of a solar cell.

In the dark, all the minority carriers in both n- and p-regions of a cell are generated by thermal excitation. Once the free electrons, minority carriers in the p-region, diffuse through the p-region to the depletion zone, they are swept by the built-in barrier potential V_b across the junction "downhill" into the n-region. In a similar manner holes, minority carriers in the n-region, are swept into the p-region. (Note that the energy band diagrams on p. 23 were drawn for electrons; for holes, the diagrams are inverted so that holes fall "downhill" as they are swept from the n-region into the p-region.) This flow of thermally generated minority carriers in a solar cell in darkness is called a "dark drift current." This current is balanced by an opposing flow of charge carriers across the junction — a "back diffusion" of majority carriers (electrons crossing from n-region to p-region, and holes crossing from p-region to n-region), flowing *against* the electrostatic potential V_b. Because majority carriers far outnumber minority carriers, V_b adjusts itself so that these two opposing currents are equal in magnitude, and equilibrium is established between the n-region and p-region. As a result, a p-n junction in the dark produces no net current.

When sunlight falls on a p-n junction solar cell while it is *short-circuited,* the magnitude of V_b remains essentially the same as it was in darkness. Because the diffusion (majority) current varies with V_b, it does not change either. However, additional minority carriers are formed by photons absorbed in both n-regions and p-regions and are swept across the junction. The flow of these minority carriers is in the same direction as the dark drift current and *is* a net *current* flow, called the photogenerated short-circuit current I_{sc}.

The same cell in sunlight, but under an *open-circuit* condition, cannot develop a net current flow. Instead, the cell achieves an equal internal flow of majority and minority carriers across the junction by reducing its electrostatic potential from its original value V_b. This reduction allows a much larger diffusion current (movement of majority carriers across the junction), which balances the photogenerated minority current I_{sc}. This decrease in barrier potential causes a voltage of the same magnitude across the open-circuit terminals of the cell, commonly called the open-circuit voltage V_{oc}. It follows that V_{oc} is equivalent to the *reduction* from the built-in barrier potential V_b. The larger I_{sc} becomes, the greater the barrier potential reduction will be. Although theoretically the maximum value V_{oc} can achieve is V_b, this condition is possible only at very high concentrations of sunlight, that is, with extremely large I_{sc}. Furthermore, since V_{oc} is a *decrease* in barrier potential, cells with a large V_b usually

produce a large V_{oc} — which is why cells with larger band gaps have large values of V_{oc}.

Under both short-circuit and open-circuit conditions, a solar cell produces no electrical power. But when a load resistance is connected to a cell, in sunlight a net current I_{ph} will flow through the load and a voltage V_{ph} will be induced across it. The existence of I_{ph} requires that the flow of majority carriers be reduced from that in the open-circuit condition. This means that there must be a higher barrier potential than in the open-circuit case. This higher barrier potential indicates a smaller reduction from V_b. Since the photogenerated voltage induced across the cell is the same as the photogenerated voltage V_{ph}, the magnitude of V_{ph} will always be less than V_{oc}.

The photogenerated current I_{ph} is in the same direction as I_{sc}, but is always less than I_{sc} because the barrier potential under load conditions is always less than V_b, resulting in a larger flow of majority carriers than that in a short-circuited cell. Thus, when a solar cell is under load, the current and voltage produced are, respectively, always less than I_{sc} and V_{oc} — a condition often called the "curve-factor loss." Depending on the characteristics of the particular p-n junction and cell operating conditions, there is an optimal load resistance that will maximize the power output of the cell, which is the product of its current and voltage.

When the temperature of a solar cell rises, cell conversion efficiency decreases. This decrease occurs because the additional thermal energy increases the thermally generated minority current (the dark drift current). The cell balances this increase in dark drift current by lowering the built-in barrier potential V_b to boost the majority diffusion current. The drop in V_b in turn causes V_{oc} and V_{ph} to decrease. Therefore, a cell's output (the product of V_{ph} and I_{ph}; I_{ph} is less sensitive to temperature changes than V_{ph}) falls as the cell gets hotter.

Why Conversion Efficiency Isn't 100 Per Cent

The most efficient silicon cells thus far produced use p-n homojunctions and convert only about 15 per cent of the energy in incident sunlight into electricity at 20°C and AM0.[19] In theory, silicon p-n junction solar cells can convert a maximum of about 22 per cent[20] of the energy in AM0 sunlight to electricity. About 73 per cent of the energy in sunlight is lost to factors intrinsic to the cell itself; an additional loss of 12 per cent in today's best cells may eventually be reduced to as little as 5 per cent (*see lower diagram on p. 28*).

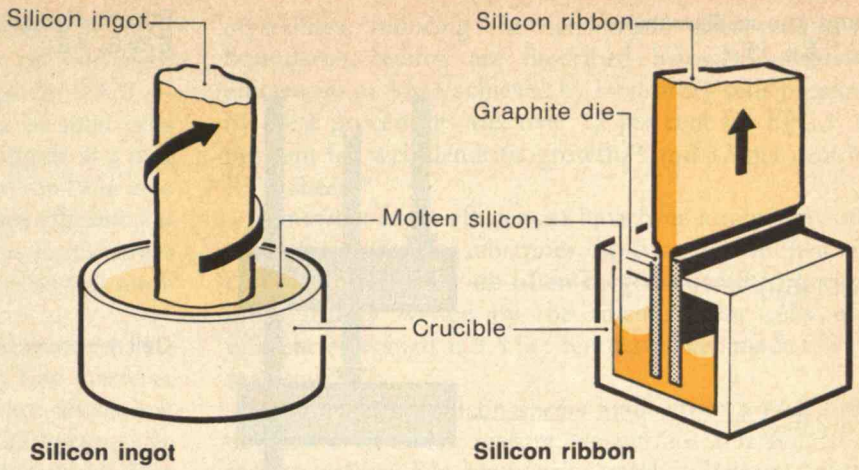
Paradoxically, the largest single loss is caused by overly energetic sunlight. About 32 per cent of sunlight contains photons with energies larger than E_g for silicon (1.1 eV), but generally only one electron-hole pair can be created by a solar photon — even one with excess energy. The energy beyond E_g is lost to the conversion process and only produces heat within the crystal. Still another 24 per cent of sunlight is useless to the conversion process because its photons have energies less than E_g and are unable to create electron-hole pairs. These percentages of loss, calculated for AM0 (sunlight in space), are less in higher air masses. When sunlight passes through the atmosphere, both extremely energetic and weak photons are lost — photons to which solar cells are least responsive. So while the higher air masses have smaller densities than the lower air masses, the remaining photons better match the response of solar cells, resulting in higher conversion efficiencies, but less total output.

As we have seen, the junction barrier energy in solar cells is always less than E_g so that the maximum photovoltage V_{oc} that can be induced is always less than 1.1 volts. For a homojunction in silicon, this loss, called the voltage-factor loss, leads to a reduction in conversion efficiency of another 11 per cent. Another reduction, the curve-factor loss discussed earlier, amounts to 6 per cent in silicon and results from the limit of power that can be obtained from a p-n junction.[20] (The maximum power is always less than the product of I_{sc} and V_{oc}.)

Other losses, which together run about 12 per cent in present-day cells, are caused by reflection, additional curve-factor and voltage-factor losses, and shading by contact bars and fingers (*see diagram on p. 28*). With improved fabrication techniques the effect of these losses eventually may be reduced to about 5 per cent.

In summary, a maximum of about 22 per cent is the limit of conversion efficiency for silicon cells at AM0. Today's best silicon cells have efficiencies of about 15 per cent at AM0 — significantly less than this limit. The loss is due mainly to additional voltage factor and curve factor losses. In comparison, p-n homojunction cells made of a number of other more costly semiconductor materials, such as indium phosphide (InP), gallium arsenide (GaAs),

Most of the silicon ingot that is slowly grown from a melt, as shown at the left, is reduced to grinding dust when the ingot is sliced up into wafers for solar cells. Subsequent polishing to remove cutting damage wastes even more of the material. In the EFG process (edge-defined film-fed growth, a process developed by Mobil Tyco Solar Energy Corp.) a thin ribbon of silicon is "pulled" from a silicon melt through a graphite die. The ribbon is then wound onto a spool, essentially ready for fabrication into solar cells. Very little material waste is incurred in the EFG process.



Silicon ingot **Silicon ribbon**

and cadmium telluride (CdTe), which have energy gaps between 1.2 and 1.4 eV, have maximum theoretical conversion efficiencies of about 26 per cent.[21] Materials having higher band gap energies, such as cadmium sulfide (CdS), will have higher photovoltage but much lower photocurrent, resulting in lower power conversion efficiency in sunlight. This reduction in photocurrent occurs because there are decreasing numbers of solar photons energetic enough to create electron-hole pairs in such materials.

Today's Commercial Silicon Solar Cells

Silicon cells are at present thicker than need be. They are hundreds of micrometers thick, although most solar radiation is absorbed in the first 20 to 30 micrometers (one micrometer = 10^{-6} meters). (Light penetration falls off exponentially, proportional to $e^{-\alpha t}$, where α is the absorption coefficient of a material and t is its thickness. The values of α for a given material vary with the wavelength of incident radiation; in silicon, α varies from 10^3 to 10^5 per centimeter, over most of the range of usable solar radiation.)

A silicon cell homojunction is usually close to the surface of the cell — about 0.5 to 1 micrometer deep. This shallowness minimizes the creation of photogenerated carriers in the layer above the junction. Such charge carriers may reach the crystal surface and recombine before being swept through the junction — greatly decreasing the photocurrent and therefore cell efficiency. (The crystal surface has many broken bonds that act as recombination centers.) The logical way to minimize this mode of recombination is to make the top layer thin, so that most of the charge-carrier generation takes place below the junction.

But thinning down the top layer increases its sheet resistance, which is approximately inversely proportional to layer thickness. If the charge carriers that are swept from the lower layer into the top layer have to pass through a large resistance before they are collected, much of their energy will be dissipated. A continuous metal sheet used on the top of the cell would reduce this sheet resistance, but such a sheet would also block the sun; techniques for using extremely thin metal sheets are being developed. Transparent conducting materials are also being investigated. One such material is a tin-doped indium oxide (In_2O_3) film also known as ITO. ITO is currently used as a heavily-doped semiconducting film about 0.5 micrometer thick that is more than 85 per cent transparent to sunlight and also highly conductive.[22,23] Sheet contacts made of such a material would greatly reduce sheet resistance and still transmit most of the sunlight to the cell itself.

At present, conventional silicon cells use a narrow metal bar connected to a number of fingers to collect charge carriers from the side of the cell facing the sun. The fingers are spaced close together to minimize resistive losses and are small enough in total area so that a minimal cell area is in their shadow.

A smooth, bare silicon surface reflects about 40 per cent of incident sunlight, making antireflection coatings necessary in solar cell applications. One typical coating consists of a single layer of a transparent dielectric material, such as silicon oxide (SiO_x) or tantalum pentoxide (Ta_2O_5), about 0.08 micrometers thick. In combination with chemically texturing the surface of the cell, such a coating can reduce reflectivity to as little as 3 per cent.[24]

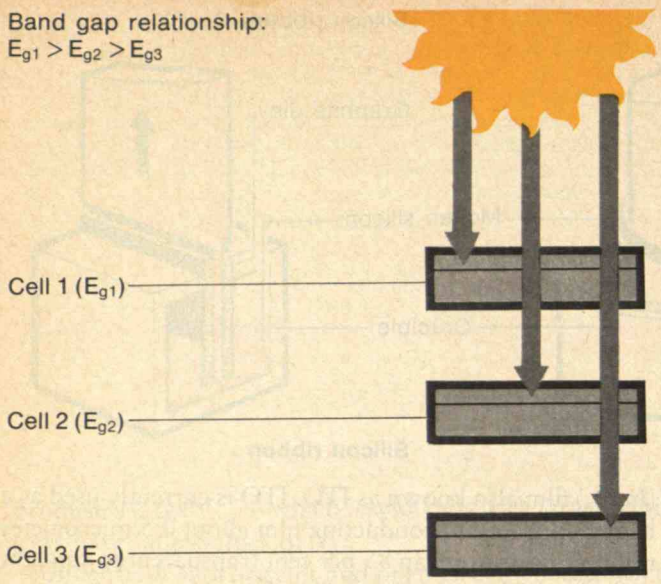
To fight environmental degradation, solar cells are encapsulated with a transparent adhesive that can also bind a protective cover glass, if one is used. Inexpensive adhesives are constantly being sought that can withstand the countless thermal cycles, and chemically and physically hostile conditions to which solar cells are subjected in the terrestrial environment. The most widely used encapsulation material is a silicone-based rubber. However, separation of such encapsulation as well as electrical contact failures in commercial solar cell modules, have been observed,[25] and improved encapsulation materials and techniques are being developed.

How to Make Solar Cells More Efficient and Less Costly

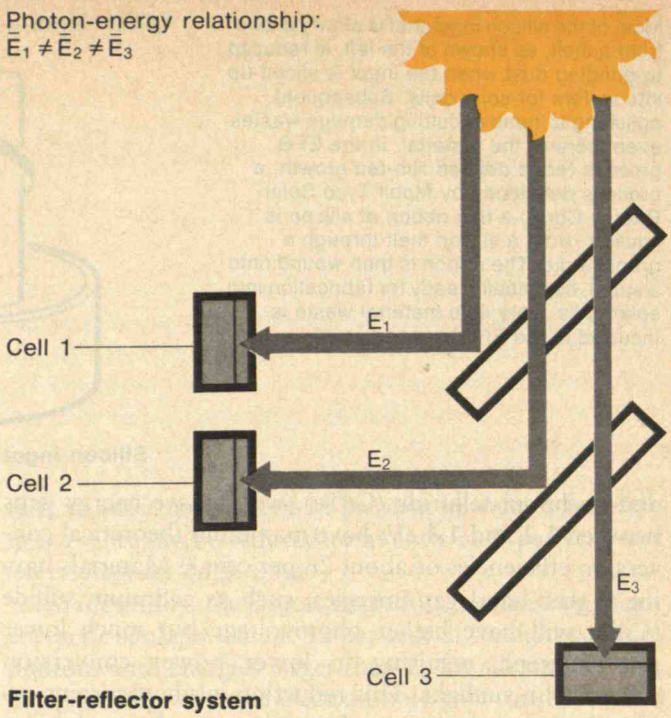
The principal challenge for solar cell researchers today is to reduce drastically the effective costs of solar cells to make possible practical, economical photovoltaic power systems. At present, there are three major approaches to this goal: developing techniques to produce low-cost silicon wafers or sheets for solar cell fabrication; building light-concentrating solar cell systems; and fabricating thin-film solar cells.

Low-Cost Silicon Wafers and Sheets

Two paths are being pursued in an effort to lower the



Tandem cell system

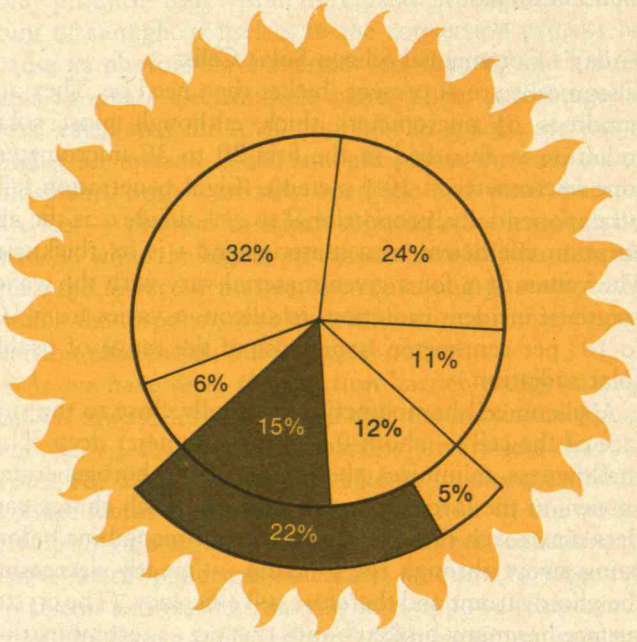


Filter-reflector system

The economics of solar cell systems using high concentrations of sunlight requires using cells of high conversion efficiencies. The solar spectrum can be split into many different ranges for conversion by cells designed for optimal response to these ranges to achieve these high efficiencies. Two methods of splitting the solar spectrum (using only three such cells for illustrative purposes) are shown here.

The diagram at the upper left shows a tandem-cell system. The energy gaps of the component cells in such a system decrease from the top cell to the bottom cell. For example, the top cell has the highest energy gap E_{g1}, so that it absorbs the high-energy portion of the solar spectrum and transmits the lower energy portions to the cells below.

The diagram at the upper right illustrates an optical filter-reflector system that splits the solar spectrum into three energy ranges $\bar{E}_1$, $\bar{E}_2$, and $\bar{E}_3$. Each range is directed onto a solar cell that is optimized for the respective energy range.



The diagram to the right shows where various fractions of energy in sunlight are lost in the photovoltaic conversion process for a p-n homojunction silicon solar cell. These losses are calculated for AM0 and 20°C. Note that today's best commercial cells can convert only about 15 per cent of the energy in sunlight into electricity; 22 per cent is the maximum efficiency estimated to be achievable by an optimally improved cell. (Data: Reference 20)

32%	**$E \geq E_g$ (highly energetic photons)**	24%	**$E < E_g$ (energy-deficient photons)**
6%	**Curve-factor loss**	11%	**Voltage-factor loss**
15%	**Maximum efficiency (today's cells)**	12%	**Additional losses (today's cells)**
22%	**Maximum achievable efficiency (tomorrow's cells)**	5%	**Additional losses (projected minimum: tomorrow's cells)**

overall cost of silicon solar cells. One is based on ingot (single-crystal) technology and the other on non-ingot (semicrystalline) technology. D.O.E.'s goal for 1978 — nearly achieved — is to produce modules of solar cells made from wafers cut from single-crystal ingots at a cost of $7 per peak watt (1975 dollars); the goal for 1986 is to produce modules of cells having 17 per cent efficiency at AM1 for 50¢ per peak watt. The chart on p. 33 shows price allocations of ingot and non-ingot solar cell modules to the year 1986.[26]

The total cost of solar cells made from ingots is the result of combining the costs of the silicon raw material, growing the ingot, cutting and polishing thin silicon wafers from the ingot, fabricating and encapsulating the cells, and then assembling them into modules. The potential for great cost cutting in ingot technology is due to two factors: the silicon presently being used is of much higher quality than necessary, and most of the crystal material is lost during the cutting and polishing operations.

Currently, ingot-type silicon solar cells are made of the high-quality semiconductor grade of silicon used in the semiconductor industry for electronic circuitry components. Complex and expensive purification processes are used to remove all significant impurities in this high grade of raw silicon, but the purity that results is greater than necessary for use in solar cells. In an effort to determine the minimal requirements of a cheaper "solar grade" of silicon, the D.O.E. is sponsoring efforts to identify kinds and amounts of impurities particularly detrimental to solar cell conversion efficiency.

Today's basic method of producing wafers from ingots is an energy-consuming, costly, and terribly wasteful process. The ingot is slowly "pulled" from a silicon melt and is then cut into thin wafers and polished, reducing over 60 per cent of the ingot to dust. A number of efforts are underway to reduce this waste, including the casting of ingots from the silicon melt and the investigation of advanced cutting techniques — for example, using multiple thin blades.

A more attractive and promising cost-cutting approach is to abandon ingots entirely and to grow good quality crystalline sheet from molten silicon. Smoothly grown sheets about 100 micrometers thick require little cutting and polishing, incurring little waste. There are two basic schemes for developing this non-ingot technology, one of which produces cells of somewhat higher conversion efficiency than the other.

Cells of relatively high efficiency have been fabricated from silicon sheets produced by growth-from-melt processes such as edge-defined, film-fed growth (EFG), web-dendritic growth, and ribbon-to-ribbon regrowth (RTR). The EFG technique consists of "pulling" a ribbon of molten silicon through a slotted die. The shape of the ribbon is determined by the orifice in the die, which is made from a material such as graphite that can be wetted by molten silicon. In the web-dendritic growth technique silicon sheet is grown like a web between two silicon "seed" crystals that are pulled from the melt. In the RTR technique silicon ribbon is improved by being passed through a laser-heated zone. This laser treatment enlarges the crystallites, reducing the detrimental effects of grain boundaries, which are described below. Conversion efficiencies at AM1 achieved by laboratory cells prepared by these procedures are: over 12 per cent for EFG,[27] 14 per cent for web-dendritic growth,[28] and 12 per cent for RTR sheet.[29]

Somewhat lower efficiencies have been attained by cells made from ceramic substrates dip-coated in molten silicon. The substrates are often carbon coated to become more readily wetted by the silicon. Solar cells with efficiencies as high as 9.5 per cent have been made of such material.[30]

Unfortunately, silicon sheets made from a melt often develop a granular texture, sometimes referred to as semicrystalline. The boundaries of the individual crystallite grains have many detrimental effects on photovoltaic conversion:

- ☐ Crystallite grain boundaries provide recombination centers for holes and electrons.
- ☐ Boundaries behave as barriers to the movement of charge carriers: "horizontal" grain boundaries effectively isolate some charge carriers from the cell junction, and charge carriers that succeed in crossing the junction still must pass through resistive grain boundaries before reaching a contact sheet or finger.
- ☐ Charge carriers can leak across the junction along grain boundaries.
- ☐ Dopants and undesirable impurities often diffuse much more rapidly along the grain boundaries than they do in single crystals, sometimes catastrophically shorting out the junction.

Refinement of fabrication techniques has enabled the growth of fairly large crystallites up to a few millimeters in extent in sheet silicon materials. But the grain boundary problem nevertheless still presents a major obstacle to the routine production of higher-efficiency non-ingot solar cells.

Concentrator Solar Cell Systems

The semiconductor industry has achieved great cost reduction by miniaturizing components, but this path is not open to makers of solar photovoltaic cells. The low energy density of sunlight requires different approaches, which are aimed at reducing cell production cost per unit of solar system output. While much effort is being focused on reducing the cost of making the cells, some researchers are following an alternative strategy to reduce overall systems cost — using optical systems to concentrate sunlight on the cells. The success of such concentration techniques could reduce the area and thus the cost of solar cells required to produce a unit of electrical power.

Concentrator optics vary from low-ratio designs such as the 10X concentration of Winston collectors,[31] which do not require elaborate tracking of the sun, to much higher-ratio systems that use parabolic mirrors or Fresnel lenses, and which require precise two-axis tracking. The technology of this variety of optical concentrating systems is still too new to permit accurate cost analyses, but it is apparent that the cost of the optics and tracking equipment can become an important economic factor.

Within certain limits the concentration strategy works. Photocurrent generated in a solar cell increases linearly with increasing light intensity within practical limits of concentration, while photovoltage increases roughly as the logarithm of the intensity increase (up to the built-in barrier voltage). The result of these combined effects can be to boost net electrical output. But the cells must be designed to develop minimal increases in resistive losses because of the increased photocurrent densities. In addition, the concentration of sunlight often leads to increased cell temperatures, which have a detrimental effect on output. Therefore, design requirements for cells working at high concentrations are quite different from ordinary cells. Cell temperatures can easily rise to the point where conversion efficiency suffers, rather than benefits, from the concentration, and for this reason some concentrator cells must be equipped with cooling systems. For example, the decrease in the conversion efficiency of ordinary silicon cells with increasing temperature is quite large, down from a theoretical maximum of about 22 per cent at 20°C to only 14 per cent at 100°C, while the theoretical maximum efficiency of GaAs cells is still about 20 per cent at 100°C (*see the graph on p. 25*). While it may be possible in the future to utilize both the electricity and heat produced in concentrator cell systems, this concept is not yet well developed, and for now the heat could be a problem.

In spite of the problems, specially designed silicon and GaAs concentrator cells have yielded promising results. Silicon cells have achieved conversion efficiencies as high as 18 per cent at AM1 with a 300X concentration of sunlight and cell temperatures of about 25°C.[32] GaAs cells have attained remarkably high efficiencies of about 24.6 per cent at AM1 with a 180X concentration of sunlight and cell temperatures of 50°C.[33] Incremental increases in conversion efficiencies for these two types of cell will probably result as refinements are made to existing designs. But radically different schemes will have to be pursued to attain much higher efficiencies.

□ *Splitting the Solar Spectrum.* Breaking up sunlight with tandem cells and filter-reflectors are two novel concentrator cell approaches that promise to boost conversion efficiency; however, these approaches are not really new: their basic principles were suggested in 1955.[34] It has long been realized that a single solar cell with one junction can convert only a fraction of the incident sunlight into useful output. The greatest fraction of the loss, as has been discussed earlier, is due to two factors: the failure of photons with $E<E_g$ to create any electron-hole pairs, and the waste of excess energy as heat from very energetic photons with $E>E_g$.

But solar cells can be tailored to be optimally efficient in certain, limited energy ranges. By dividing the solar spectrum into such energy ranges and making each range incident upon appropriately designed cells, great improvements in overall conversion efficiency may be realized.

In one approach, solar cells with different energy gaps are stacked in tandem so that the top cell — the one facing the sun — has the largest energy gap. This cell absorbs all the photons at and above its energy gap and transmits less energetic photons to the cells below. The next cell down in the stack absorbs all the photons with energies equal to or greater than its energy gap, and transmits the rest downward in the stack, and so on. In principle any number of cells can be used in tandem. The maximum achievable efficiency of a three-cell stack is estimated to be about 35 to 40 per cent at AM1 with a 1,000X concentration of sunlight.[35,36]

The promise of high conversion efficiency from tandem cells has prompted the D.O.E. to sponsor efforts to surmount problems inherent in their design and fabrication. The sponsorship is welcome; designing tandem cells is a particularly complex exercise. For example, each cell must efficiently transmit the insufficiently energetic photons so that the contacts on the backs of the upper cells must be transparent to these photons and therefore cannot be made of the usual bulk metal layers. Unless the cells in a stack can be fabricated monolithically — together on the same substrate — different external load circuits must be provided for each cell. But monolithic cells have problems of their own. The thicknesses and band gaps of each individual cell in the stack must be adjusted so that the photocurrents in all cells are equal. Such an optimal adjustment is especially difficult because the power in different parts of the solar spectrum varies under ambient conditions.

Optical filter-reflector systems can be used to split the solar spectrum into several different energy ranges, directing each range upon cells that are optimally designed for that particular range. The maximum achievable conversion efficiency possible with this approach at a 1,000X concentration of sunlight is estimated to be about 40 per cent.[37] Unlike stacked tandem cells, the cells in filter-reflector systems do not have to be arranged in order of decreasing energies, but there are still problems to be overcome. Individual external circuit loads are still likely to be needed for each constituent cell. Optical systems are always less than perfect, and some light energy is lost in the filtering and reflection processes. Not only is this loss detrimental to performance, but it also can lead to heating problems in the optics as absorbed light is converted to thermal energy.

One filter-reflector setup using two cells recently achieved a 28.5 per cent conversion efficiency at about AM1 with a 165X concentration.[38] One of the cells was silicon, with an energy gap of 1.1 eV, and the other was gallium aluminum arsenide ($Ga_{1-x}Al_xAs$), with x = 0.2, and with an energy gap of 1.65 eV. Excluding optical losses (which were included in this experimental result), the conversion efficiency of the two-cell system would be about 31 per cent, far beyond the capability of non-concentrator silicon cells.

Thin-Film Cells

The cost of solar cells — in particular the cost of materials — will be greatly reduced if thin-film cells with small crystallites can be fabricated with good conversion efficiencies. Currently, the D.O.E. is sponsoring research and development programs to help understand the properties of thin-film cells made of Si, copper sulfide/cadmium sulfide (Cu_xS/CdS) and GaAs, and to improve their conversion efficiencies. The major goal of these programs is to demonstrate the feasibility of producing low cost, stable thin-film solar cells of over 10 per cent conversion efficiency by 1980. Other programs have also been initiated to study such promising new thin-film materials as InP,[39] CdTe,[40] zirconium phosphide (Zr_3P_2),[41] and copper indium selenide ($CuInSe_2$).[42]

Despite the difficulties encountered in thin-film cells, encouraging results have been obtained from cells of various materials, including polycrystalline Si, amorphous silicon-hydrogen (Si-H) alloy, Cu_xS/CdS, and GaAs.

☐ *Polycrystalline Si.* As stated earlier, Si absorbs sunlight poorly. For efficient absorption, thin-film Si cells should be at least 20 to 30 micrometers thick. Such thickness will require photogenerated charge carriers to diffuse similar distances to reach the junction. To minimize recombination and loss of these carriers, efficient polycrystalline cells should have as few "horizontal" grain boundaries as possible within the absorption zone. Far preferable are crystallite grain boundaries that are "vertical" — normal to the substrate. The lateral extent of crystallites should be at least three or four times greater than the absorption distance so that the "vertical" grain boundaries will not significantly reduce the photocurrent through recombination. For efficient absorption of sunlight, the thickness of a thin-film Si cell should be at least 20 to 30 micrometers, with columnar crystallites 100 micrometers across.

These requirements are quite stringent, and the proper fabrication technique has been elusive. Presently the best thin-film Si cells are about 9.5 per cent efficient at AM1,[43] much lower than the best efficiency at AM1 for single-

Junctions and How They Are Made

Four different types of junctions can be used to separate the charge carriers in solar cells:

☐ A *homojunction* joins semiconductor materials made of the same substance. For example, the homojunction of a p-n silicon solar cell separates two oppositely doped layers of silicon.

☐ A *heterojunction* is formed between two dissimilar semiconductor substances as, for example, copper sulfide (Cu_xS) and cadmium sulfide (CdS) in Cu_xS/CdS solar cells.

☐ A *Schottky junction* joins a metal and a semiconductor material.

☐ A *metal-insulator-semiconductor junction (MIS)* sandwiches a thin oxide layer, less than 0.003 micrometers thick, between a metal and a semiconductor material.

Several fabrication methods can be used to make these junctions. For example, a homojunction on a silicon wafer can be made as follows:

☐ In the *solid-state diffusion process,* an n-type wafer is heated to a temperature below its melting point and placed in contact with the vapor of a desired p-type dopant. The dopant atoms thermally migrate, or diffuse, into the wafer until the p-dopant concentration converts the top surface layer of the wafer into a p-layer, thus forming a p-n junction.

☐ The p-type dopant ions may be accelerated to high velocities in a vacuum and then injected into the n-type wafer — a method called *ion implantation.*

☐ The p-n junction can be formed by actually growing a p-type layer on the n-type wafer using various techniques. In *chemical vapor deposition,* vapors of silicon atoms and atoms of the p-dopant are deposited on the n-type wafer, generally at atmospheric pressure. In *vacuum deposition,* vapors of silicon and p-dopant atoms are deposited on the n-type wafer in a vacuum. In *liquid phase deposition,* the p-type layer is grown on the n-type wafer from a silicon melt that contains the p-dopant.

While all the above processes can produce a p-n homojunction, the properties required from the junction, as well as fabrication costs, will determine the method selected. Methods of making other kinds of junctions are similar to those used to make homojunctions but, of course, materials to either side of such junctions are dissimilar — *J.C.C.F.* ☐

Junction	Method of fabrication
Homojunction	diffusion process ion implantation chemical vapor deposition vacuum deposition liquid phase deposition
Heterojunction	chemical vapor deposition vacuum deposition liquid phase deposition
Schottky junction	vacuum deposition
MIS junction	vacuum deposition

crystal Si of 18 to 19 per cent.[44] These polycrystalline thin-film Si cells are grown by chemical vapor deposition on recrystallized metallurgical silicon substrates, and are about 20 to 30 micrometers thick with crystallites varying up to several hundred micrometers in lateral extent.

□ *Amorphous Silicon-Hydrogen Alloy (Si-H).* Recently, solar cells fabricated from amorphous (lacking a crystalline structure) silicon-hydrogen films were reported to have operated with a conversion efficiency of 5.5 per cent.[45] This result is intriguing because amorphous Si-H solar cells have been estimated to have conversion efficiencies as high as 15 per cent[46] and have attributes well suited for solar cell fabrication. For example, they have no crystallites and therefore no grain boundaries, avoiding grain boundary effects. They strongly absorb sunlight, and need be only about 1 micrometer thick to almost totally absorb sunlight. The material costs and the costs of cell fabrication procedures could be low.

Presently, the best amorphous Si-H cells have up to 50 atomic per cent of hydrogen, so that this material can be considered an alloy of the two elements. In the hydrogenation process the hydrogen atoms are generally believed to attach themselves strongly to the broken covalent silicon bonds, which are intrinsic to amorphous silicon films. The strength of the silicon bonds holding hydrogen atoms eliminates many free bond trapping centers and also suggests that solar cells made of this alloy may be stable and long-lived under nonconcentrating operating conditions.

Unfortunately, efforts to further reduce the trapping centers have been unsuccessful so far. Sunlight generates carriers to a depth of up to 1 micrometer in amorphous Si-H, but only carriers generated within a fraction of this depth can actually diffuse to the cell junction. Many are trapped by remaining broken silicon bonds. Obviously, this entrapment greatly reduces the photocurrent.

Photocurrent may be increased by using various material preparation techniques, such as the introduction of other gases to reduce the number of trapping centers, and by increasing the ability of the material to absorb light. The latter approach may produce films that can absorb all the sunlight in fractions of a micrometer, which is comparable to the distance that photogenerated carriers can diffuse. The application of these approaches to silicon, as well as other materials, has opened exciting research areas in the development of new kinds of low-cost, efficient solar cells.

□ *Cu_xS/CdS.* Various methods of fabricating thin-film solar cells from these materials exist. The most common method is based on a simple process of serially overcoating a metal substrate, often copper.[47] The substrate first is overcoated with zinc. The zinc serves as an ohmic contact between the copper and a 30-micrometer-thick vapor-deposited layer of polycrystalline CdS. A layer of Cu_xS is then formed on the CdS base by dipping the unit into hot cuprous chloride and then heat treating in air. A heterojunction then exists between the CdS and Cu_xS layers.

Most of the sunlight is absorbed by the Cu_xS layer, so that the CdS layer need not be very thick, because it need not absorb much sunlight. However, with the present fabrication process the CdS layer must be thick enough to prevent the Cu_xS from diffusing along the grain boundaries deeply enough to reach the metal substrate, thus short-circuiting the heterojunction.

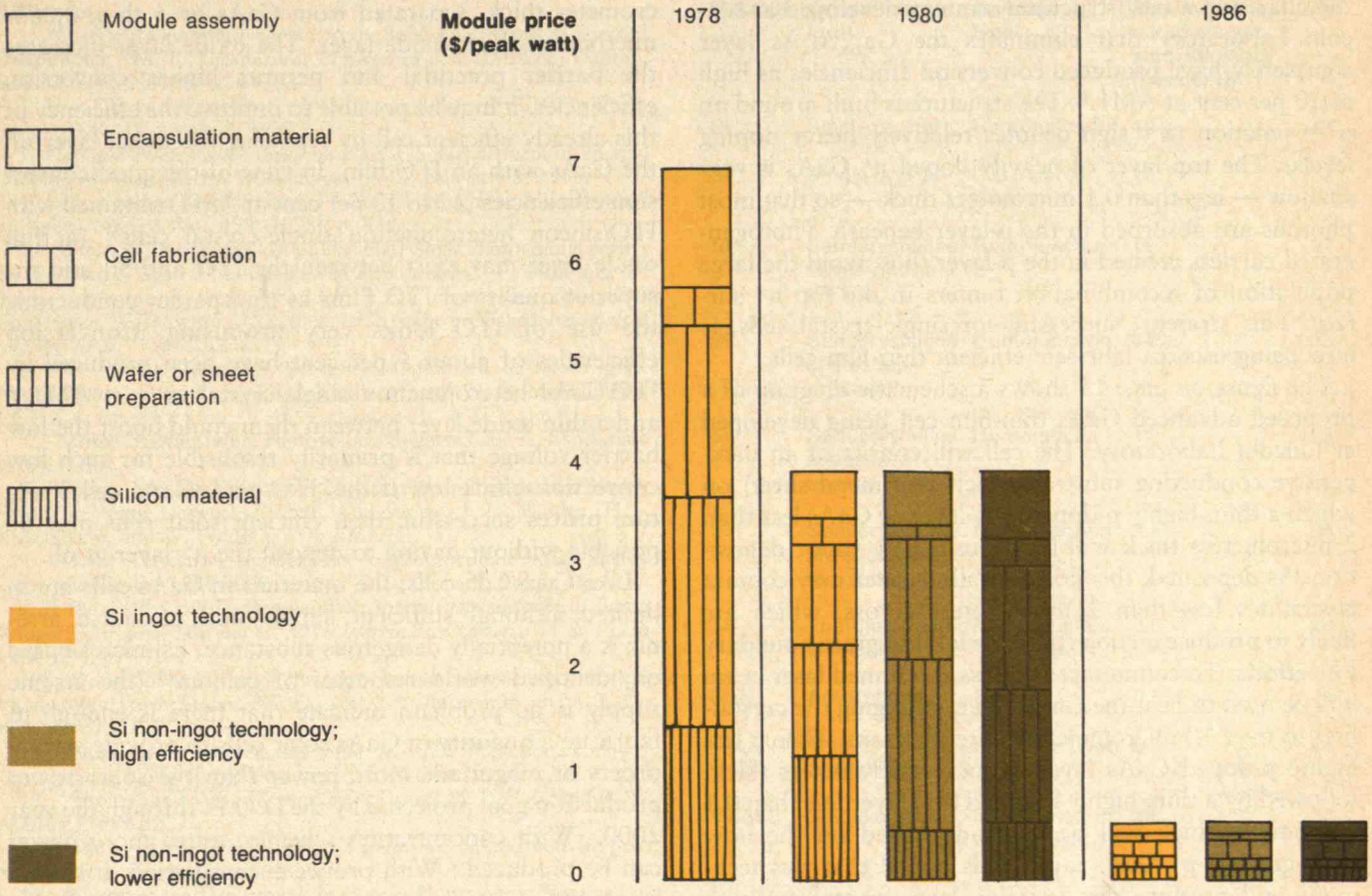
A laboratory Cu_xS/CdS cell has produced a noteworthy conversion efficiency of about 8.6 per cent in sunlight.[48] However, extended performance of this type of cell may be unstable because the conversion efficiency is very sensitive to the chemical composition of the Cu_xS, with best results obtained for $x = 2$, that is, with twice the number of copper atoms as sulfide atoms in the crystal structure. With this composition, the Cu_2S band gap is about 1.2eV.[47] Despite the problems, because these cells are relatively easy and inexpensive to fabricate, they are major candidates for further research and development efforts.

When using materials other than silicon for solar cells, we are faced with problems of material availability as well as environmental safety. For example, the world's resources of cadmium[49] are much less than those of silicon, but are still several orders of magnitude greater than the amount needed to provide the total solar photovoltaic power production goal estimated through the year 2000. While the toxicity of cadmium could pose a health and safety problem, it should be possible to encapsulate cells containing the material successfully to preclude its contact with the environment.

□ *Gallium Arsenide (GaAs).* Gallium arsenide is emerging as a very promising material for both high-efficiency single-crystal and thin-film solar cells. It is superior to silicon in several respects. The band gap E_g of GaAs, about 1.4 eV, is higher than silicon's 1.1 eV and is in the range that gives the highest calculated conversion efficiency for a single-crystal, single-junction cell — about 26 per cent at AM0, compared to 22 per cent for silicon. Because of this high efficiency and because the efficiency does not degrade nearly so rapidly as does that of silicon cells with increasing temperatures, GaAs single-crystal cells are being seriously considered for use as concentrator cells.

GaAs solar cells could weigh much less than silicon cells of similar output because GaAs absorbs sunlight

To meet the goals set by the D.O.E., the price of silicon solar cell modules must be reduced by more than an order of magnitude in less than 10 years. The price of a solar cell module can be broken into five separate components for both ingot and non-ingot technologies. This chart illustrates the drastic reduction needed for each of these components so as to achieve the overall price goals. (Data: Reference 26)



much more readily than silicon. In fact, GaAs absorbs sunlight orders of magnitude more efficiently than silicon, so that thin layers only 1 to 2 micrometers thick would do the same job as much thicker — and heavier — layers of silicon (*see the graph on p. 25*). The high efficiency and light weight of GaAs solar cells have made them promising candidates to be used in future space vehicles.[50]

Thin-film polycrystalline GaAs solar cells only 1 to 2 micrometers thick and with lateral crystallites over 10 micrometers across may attain up to 15 per cent conversion efficiency at AM1.[51] Current cells, which are still in their early stages of development, have actually achieved about 5.5 per cent efficiency at AM1.[52]

Three different high-efficiency types of GaAs cell structures are currently being developed: GaAs homojunctions with a top "window" layer of $Ga_{1-x}Al_xAs$, GaAs shallow-homojunctions, and GaAs MIS junctions. Each type is aimed at minimizing the effects of the recombination of charge carriers at the site of broken bonds in the top surface. Such recombination effects — more severe in GaAs than in silicon because of the shallower absorption depth of sunlight in GaAs — can severely reduce the photocurrent and therefore the conversion efficiency.

One very successful approach that reduces this surface recombination effect is to apply a thin layer of p-doped $Ga_{1-x}Al_xAs$ on the top surface of a p-n junction GaAs cell. This thin layer of $Ga_{1-x}Al_xAs$ transmits almost all the solar spectrum and forms an effective solar "window." It also matches up with the GaAs lattice very well, greatly reducing the number of broken bonds at the GaAs surface. Single-crystal cells built in this manner have produced conversion efficiencies as high as 21 to 22 per cent.[53] Unfortunately, in thin-film cells the p-dopants in the $Ga_{1-x}Al_xAs$ layer appear to diffuse down the grain boundaries and short-circuit the junction.[54] Research efforts are being directed at solving this problem, either by finding a dopant that does not diffuse so rapidly or, since n-dopants in GaAs tend to diffuse more slowly than p-dopants, by inverting the cell structure so that a layer of n-type $Ga_{1-x}Al_xAs$ is on top of an n-p GaAs configuration.

Cells using a new structural strategy developed at Lincoln Laboratory that eliminates the $Ga_{1-x}Al_xAs$ layer completely have produced conversion efficiencies as high as 20 per cent at AM1.[55] The structure is built around an n^+-p junction (a $^+$ sign denotes relatively heavy doping levels). The top layer of heavily doped n^+ GaAs is very shallow — less than 0.1 micrometer thick — so that most photons are absorbed in the p-layer beneath. Photogenerated carriers created in the p-layer thus avoid the large population of recombination centers in the top n^+ surface. This strategy, successful for single-crystal cells, is now being used to fabricate efficient thin-film cells.

The figure on page 15 shows a schematic diagram of a proposed advanced GaAs thin-film cell being developed at Lincoln Laboratory. The cell will consist of an inexpensive conducting substrate (such as a metal sheet) on which a thin, highly p-doped (p^+) layer of GaAs less than 2 micrometers thick will be deposited by vapor deposition. As deposited, this polycrystalline layer may contain crystallites less than 2 micrometers across, which are likely to produce an objectionable level of grain boundary loss effects. To counteract this loss, a scanned laser beam will be used to heat the GaAs layer, enlarging the crystallites to over 10 micrometers in lateral extent. Then a less highly p-doped GaAs layer about 2 micrometers thick, followed by a thin, highly n-doped (n^+) layer less than 0.1 micrometer thick will be vapor-deposited on the now large-grained p^+ GaAs layer. It is hoped that this technique will produce the desirably large crystallites with columnar growth that minimize the resistance encountered by charge carriers diffusing to the junction.

The shallow homojunction between n^+ layer and p layer will minimize the recombination effects in the top n^+ surface, while the strongly doped p^+ layer will provide an electric "back surface field" that helps push the holes in the p layer to the junction, effectively reducing recombination at the back surface. The cell will then be overcoated with a transparent, highly conductive film such as a tin-doped indium oxide film (ITO), which serves as an excellent contact. The application of the ITO overlayer on polycrystalline cells will greatly reduce the series resistive losses, because carriers generated in the p layer can reach the ITO layer easily through the n^+ layer, and do not have to cross grain boundaries. As an added bonus, transparent conducting films like ITO usually have helpful antireflection properties, further enhancing the absorption of sunlight.

This shallow $n^+/p/p^+$ homojunction structure is quite different from the MIS structure used in single-crystal GaAs cells, which have obtained conversion efficiencies of 16 to 17 per cent at AM1.[56] The structure of the MIS junction cell consists of a thin metal film about 0.005 micrometer thick, separated from GaAs by a thin, 0.003-micrometer-thick oxide layer. The oxide layer increases the barrier potential and permits higher conversion efficiencies. It may be possible to improve the efficiency of this already efficient cell by replacing the metal layer on the GaAs with an ITO film. In view of the good conversion efficiencies (12 to 13 per cent at AM1) obtained with ITO/silicon heterojunction single-crystal cells[57] (a thin oxide layer may exist between the ITO and Si) and the superior quality of ITO films as transparent conductors, the use of ITO looks very promising. Conversion efficiencies of about 5 per cent have been produced by ITO/GaAs heterojunction single-crystal cells at AM1,[58] and a thin oxide layer between them could boost the low barrier voltage that is primarily resonsible for such low conversion efficiency. If this ITO/oxide/GaAs cell structure proves successful, then efficient solar cells may be possible without having to deposit the n^+ layer at all.

Like Cu_xS/CdS cells, the materials in GaAs cells are in limited, although sufficient, supply, and, of course, arsenic is a potentially dangerous substance. Estimates based on identified world resources of gallium[49] (the arsenic supply is no problem) indicate that there is enough to fabricate a quantity of GaAs solar cells to provide several orders of magnitude more power than the solar power production goal projected by the D.O.E. through the year 2000. (With concentration schemes, much more power can be produced.) With proper encapsulation, it should be possible to minimize the danger in using such cells for terrestrial applications.

Summary and Outlook

The price of solar cell modules has dropped over an order of magnitude in the past five years. But the next order-of-magnitude drop will be much harder to achieve. Innovation and hard work, supported by sufficient funding from government and industry, will be needed to continue the rapid progress already made in lowering solar cell costs and in improving conversion efficiencies.

The table on p. 35 shows the latest measured efficiencies of some popular cells. Undoubtedly, further technological breakthroughs will cause this sampling of today's state-of-the-art cells to be rapidly outdated. The "ultimate" cell may not even use the structures or materials discussed in this article. For example, the possibility of fabricating solar cells from organic materials[59] and polymer materials[60] is intriguing. Indeed, the prospects of obtaining low-cost, efficient solar cell modules are bright. In addition, the many virtues inherent in the direct conversion of sunlight into electricity will help to accelerate the adoption of this essentially inexhaustible mode of power production.

References

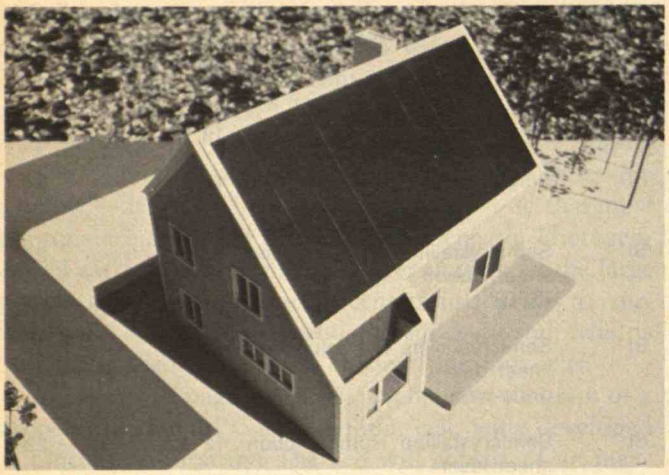
1. "Survey of Quantitative Data on the Solar Energy and its Spectral Distribution," M. P. Thekaekara, Conference of COMPLES, Dahran, Saudi Arabia, November, 1975.
2. U. S. Department of Energy Information Release R-77-071, Washington, D.C., December 5, 1977.
3. *National Photovoltaic Program Plan,* U.S. Department of Energy, Division of Solar Energy, Washington, D. C., February 3, 1978.
4. "Photovoltaic Power Systems: A Tour Through the Alternatives," H. Kelley, *Science,* Vol. 199 (1978), p. 634.
5. "Effects of Design on Cost of Flat-Plate Solar Photovoltaic Arrays for Terrestrial Central Station Power Applications," P. Tsou and W. Stolte, *Conference Record of the 13th I.E.E.E. Photovoltaic Specialists Conference,* Washington, D.C., June, 1978 (to be published; *hereinafter referred to as "13th I.E.E.E.").*
6. "An Inverter/Controller Subsystem Optimized in Photovoltaic Applications," R. L. Pickrell, G. O'Sullivan, and W. C. Merrill, *13th I.E.E.E.*
7. "Motor Starting with Photovoltaic Systems," E. E. Landsman, *13th I.E.E.E.*
8. "Energy Storage Operation of Combined Photovoltaic/Battery Plants in Utility Networks," C. R. Chowaniec, J. L. Maitlen, H. S. Kirschbaum, and W. Feduska, *13th I.E.E.E.*
9. "Major Terrestrial Applications for Photovoltaic Solar Energy Conversion in the 1980-2000 Period," S. L. Leonard, *Conference Record of the 12th I.E.E.E. Photovoltaic Specialists Conference,* Baton Rouge, Louisiana, November, 1976 *(hereinafter referred to as "12th I.E.E.E."),* p. 641.
10. "Design of the Natural Bridges National Monument 100 kW Photovoltaic Power System," E. F. Lyon, L. L. Bucciarelli, and A. E. Benoit, *13th I.E.E.E.*
11. "Design and Construction of a 50 KVA Photovoltaic Power Conditioning Unit," J. M. Urish and J. L. Watkins, *13th I.E.E.E.*
12. "Photovoltaic Power System Field Tests," M. D. Pope and R. W. Martin, *13th I.E.E.E.*
13. "Status of the Photovoltaic Concentrator Applications Experiments," E. L. Burgess, *13th I.E.E.E.*
14. "Status of the Department of Energy Photovoltaic Systems Engineering and Analysis Project," D. G. Schueler, *13th I.E.E.E.*
15. "Description and Status of N.A.S.A. Lewis Research Center/ Department of Energy Photovoltaic Applications Systems Experiments," A. F. Ratajczak, *13th I.E.E.E.*
16. "Military Applications of Solar Cell Power," J. W. Bond, Jr., *12th I.E.E.E.,* p. 725.
17. "Photovoltaic Rural Telephonic Station Realized Under Mexican Technology," E. J. Perez, J. L. Del Valle Padilla, A. Urbano, E. Servin, and H. Romero, *13th I.E.E.E.*
18. "Solar Photovoltaic Cells in Developing Countries," C. Weiss, *12th I.E.E.E.,* p. 1003.
19. "The Comsat Non-Reflective Silicon Solar Cell: A Second Generation Improved Cell," J. G. Haynos, J. F. Allison, R. A. Arndt, and A. Meulenberg, Jr., International Conference on Photovoltaic Power Generation, Hamburg, Germany, September 25-27, 1974; "Thin Silicon Solar Cell Performance Characteristics," C. F. Gay, *13th I.E.E.E.*
20. "A New Look at Silicon Solar Cell Performance," M. Wolf, *Energy Conversion,* Vol. 11 (1971), p. 63.
21. "Effects of Temperature on Photovoltaic Solar Energy Conversion," J. J. Wysocki and P. Rappaport, *J. Appl. Phys.,* Vol. 31 (1960), p. 571.
22. "X-ray Photoemission Spectroscopy Studies of Sn-Doped Indium-Oxide Films," J. C. C. Fan and J. B. Goodenough, *J. Appl. Phys.,* Vol. 48 (1977), p. 3524.
23. "Effects of O_2 pressure during deposition on properties of rf-sputtered Sn-doped In_2O_3 films," J. C. C. Fan, F. J. Bachner, and G. H. Foley, *Appl. Phys. Lett.,* Vol. 31 (1977), p. 773.
24. "Optical Properties of the Comsat Non-Reflective Cell," R. A. Arndt, J. F. Allison, J. G. Haynos, and A. Meulenberg, Jr., *Conference Record of the 11th I.E.E.E. Photovoltaic Specialists Conference,* May, 1975, Scottsdale, Arizona, p. 40.

Material	Crystalline form	Junction type	Maximum measured conversion efficiency (per cent)	Ref.
Si	Single crystal	Homojunction	19	44
Si	Single crystal	ITO heterojunction	13	57
Si	Semicrystalline sheet: ribbon (EFG)	Homojunction	12	27
Si	Semicrystalline sheet: dendritic-web	Homojunction	14	28
Si	Semicrystalline sheet: laser-treated RTR	Homojunction	12	29
Si	Semicrystalline sheet on ceramic substrate	Homojunction	9.5	30
Si	Thin-film polycrystalline	Homojunction	9.5	43
Si-H	Amorphous	MIS	5.5	45
Cu_xS/ CdS	Thin-film polycrystalline	Heterojunction	8.6	48
GaAs	Single crystal	Homojunction with $Ga_{1-x}Al_xAs$ window	22	53
GaAs	Single crystal	Shallow homojunction without $Ga_{1-x}Al_xAs$ window	20	55
GaAs	Single crystal	MIS	17	56
GaAs	Single crystal	ITO heterojunction	5	58
GaAs	Thin-film polycrystalline	MIS	5.5	52

These solar cell conversion efficiencies were recorded by different laboratories under what is assumed to be room temperature, AM1 conditions, with no concentration of sunlight, and including losses due to reflection and contact finger resistance.

It should be pointed out that the difference between semicrystalline and polycrystalline materials is not well defined. In general, semicrystalline materials have large crystallites millimeters across, while polycrystalline materials have much smaller crystallites. (Data: sources as noted by reference numbers in column of references)

The south-facing roof of this model New England home is shingled with modules of solar cells. The M.I.T. Energy Laboratory calculates that such an array of cells could supply roughly 30 per cent of the electricity required by such a home in the New England area. The design concept was developed by Lincoln Laboratory; the building was designed by Massdesign Architects and Planners, Inc.



25. "Field Testing and Evaluation of Photovoltaic Module Performance," S. E. Forman, *13th I.E.E.E.*

26. "Price Allocation Guidelines," R. W. Aster, Jet Propulsion Laboratory, Document No. 5101-68, May, 1978.

27. "Large Area Silicon Sheet by EFG," Mobil-Tyco Solar Corp. Document ERDA-JPL-954355-77/4, December, 1977, and personal communication, A. L. Mlavsky, July, 1978.

28. "Development of Dendritic Web Silicon for Solar Cell Applications," R. G. Seidensticker, R. H. Hopkins, J. P. McHugh, C. S. Duncan, P. D. Blais, J. R. Davis, Jr., and R. Rohatgi, *13th I.E.E.E.*

29. "Studies of RTR Silicon Grown at High Speed," A. Baghadi, R. W. Gurlter, R. Legge, R. J. Ellis, and B. Sopori, *13th I.E.E.E.*

30. "Evaluation and Modeling of Si-on-Ceramic Solar Cell," J. D. Zook, S. B. Schuldt, R. B. Maciolek, and J. D. Heaps, *13th I.E.E.E.*

31. "Principles of Solar Concentrators of a Novel Design," R. Winston, *Solar Energy,* Vol. 16 (1974), p. 89.

32. "Performance of Si and GaAs Concentration Cells," S. P. Robb, D. T. O'Donnell, T. T. Rule, R. W. Sanderson, and C. E. Backus, *13th I.E.E.E.*

33. "High Efficiency AlGaAs/GaAs Concentrator Solar Cell Development," R. Sahai, D. D. Edwall, and J. S. Harris, *13th I.E.E.E.*

34. "Maximum Efficiency of Solar Energy Conversion by Quantum Processes," D. Trivich and P. A. Flinn, in *Solar Energy Research,* F. Daniels and J. A. Duffie, *eds.* University of Wisconsin Press, 1955, p. 143.

35. "Novel Materials and Devices for Sunlight Concentrating Systems," H. J. Hovel, *IBM Journal of Research and Development,* Vol. 22 (1978), p. 112.

36. "Analysis of Multiple-cell Concentrator/Photovoltaic Systems," A. Bennett and L. C. Olsen, *13th I.E.E.E.*

37. "The Potential for Increasing the Efficiency of Photovoltaic Systems by using Multiple Cell Concepts," N. S. Alir, C. E. Backus, and G. W. Masden, *12th I.E.E.E.,* p. 948.

38. "Performance of Individual Solar Cells with Different Bandgaps, Applicable to Multigap Solar Cells," R. L. Moon, L. W. James, H. A. VanderPlas, Y. G. Chai, and G. A. Antypas, *13th I.E.E.E.*

39. "The Properties of Homoepitaxial InP Films prepared by the Mo-CVD Process for the Fabrication of Heterojunction Solar Cells," H. M. Manasevit, K. L. Hess, J. J. Yang, A. G. Campbell, R. E. Johnson, L. A. Moudy, R. H. Bube, L. B. Fabick, A. L. Fahrenbruch, and M. J. Tsai, *13th I.E.E.E.*

40. "Ceramic Thin Film CdTe Solar Cell," N. Nakayama, H. Matsumoto, K. Yamaguchi, S. Ikegami, and Y. Hioki, *Japan. J. Appl. Phys.,* Vol. 15 (1976), p. 2281.

41. "Zn_3P_2: A Promising Photovoltaic Material," A. Catalano, V. Dalal, E. A. Fagan, R. B. Hall, J. V. Masi, J. D. Meakin, G. Warfield, N. Convers Wyeth, and A. M. Barnett, *13th I.E.E.E.*

42. "Thin Film $CuInSe_2$/CdS Heterojunction Solar Cells," L. L. Kazmerski, F. R. White, and G. K. Morgan, *Appl. Phys. Lett.,* Vol. 29 (1976), p. 268.

43. "Thin Film Polycrystalline Silicon Solar Cells," T. L. Chu, S. S. Chu, E. S. Stokes, C. C. Lin, and R. Abdernassoul, *13th I.E.E.E.*

44. "Development of 20-Per Cent Efficient Solar Cell," J. Lindmayer, National Science Foundation Report NSF-RANN-75-309, Washington, D. C., 1975.

45. "Amorphous Silicon Solar Cells," D. E. Carlson, *I.E.E.E. Trans. Electron. Devices,* ED-24 (1977), (No. 4), p. 449.

46. "Amorphous Silicon Solar Cell," D. E. Carlson and C. R. Wronski, *Appl. Phys. Lett.,* Vol. 28 (1976), p. 671.

47. "Direct Conversion of Solar Energy Through Photovoltaic Cells," A. Rothwarf and K. W. Böer, *Progress in Solid State Chemistry,* Vol. 10 (1975), p. 71.

48. "Development of a Thin-Film Polycrystalline Solar Cell for Large Scale Terrestrial Use," University of Delaware, in Dept. of Energy Report No. E (49-18) 2538, FR77, Washington, D.C., 1977.

49. *Semiconductors and Semimetals,* H. Hovel, in Vol. 2, "Solar Cells," New York: Academic Press, 1975, p. 222.

50. "Potential of GaAs Solar Cells for Air Force Space Power Systems," C. Stuerke, *12th I.E.E.E.,* p. 591.

51. "Outlook for GaAs Terrestrial Photovoltaics," J. M. Woodall and H. J. Hovel, *J. Vac. Sci. Techn.,* Vol. 12 (1975), p. 1000.

52. "Thin-Film GaAs Solar Cells on Tungsten/Graphite Substrates," S. S. Chu, T. L. Chu, and H. T. Yang, *Appl. Phys. Lett.,* Vol. 32 (1978), p. 557.

53. "An Isothermal Etchback-Regrowth Method for High Efficiency $Ga_{1-x}Al_xAs$-GaAs Solar Cells," J. M. Woodall and H. J. Hovel, *Appl. Phys. Lett.,* Vol. 30 (1977), p. 492.

54. "The Properties of Polycrystalline GaAs Materials and Devices for Terrestrial Photovoltaic Energy Conversion," P. D. Dapkus, R. D. Dupuis, R. D. Yingling, J. J. Yang, L. A. Moudy, R. E. Johnson, A. G. Campbell, H. M. Manasevit, and R. P. Ruth, *13th I.E.E.E.*

55. "Simplified Fabrication of GaAs Homojunction Solar Cells With Increased Conversion Efficiencies," J.C.C. Fan, C. O. Bozler, and R. L. Chapman, *Appl. Phys. Lett.,* Vol. 32 (1978), p. 390.

56. "High Efficiency GaAs Solar Cells," R. Stirn, *Proceedings of the Photovoltaic Program Semi-Annual Review, Advanced Materials R & D Branch, Dept. of Energy,* Golden, Colo., October 4-6, 1977, p. 571.

57. "Efficient Photovoltaic Heterojunctions of ITO on Si," J. B. DuBow, D. E. Burk, and J. R. Sites, *Appl. Phys. Lett.,* Vol. 29 (1976), p. 494; "Characteristics of Oxide Semiconductor on Silicon Heterostructure Solar Cells," J. B. DuBow, *Proceedings of the Photovoltaic Program Semi-Annual Review,* Advanced Materials R & D Branch, October, 1977, Golden, Colorado, p. 263.

58. "ITO/InP and ITO/GaGaS Solar Cells," K. L. Bachmann, W. R. Sinclair, F. A. Thiel, H. Schrieber, Jr., P. H. Schmidt, E. G. Spencer, E. Buehler, and K. Streeharsha, *13th I.E.E.E.*; "ITO/GaGas Solar Cells," J.C.C. Fan (to be published).

59. "Organic Solar Cells of Hydroxyl Squarylium," V.Y. Merritt and H. J. Hovel, *Appl. Phys. Lett.,* Vol. 29 (1976), p. 414.

60. "Polyacetylene, $(CH)_x$: n-type and p-type Doping and Compensation," C. K. Chiang, S. C. Gau, C. R. Fincher, Jr., Y. W. Park, A. G. MacDiarmid, and A. J. Heweger, *Appl. Phys. Lett.,* Vol. 33 (1978), p. 18.

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The Kinetics of Diet and Culture

Even though urbanization has widened the choice of foods available to city dwellers, their nutrition may actually deteriorate as a result.

Sanford A. Miller

With the exception of the rat, no animal seeks and consumes a greater spectrum of food than does mankind. In this, humans surpass the rat: they alone can manipulate their environment, and bring about changes that, at least in the short term, enhance their chances of survival.

Yet in spite of this strategic advantage, mankind's larder has never been comfortably stocked. Even today, relatively minor environmental changes can result in the death of millions of people — not because of their lack of ability to adapt to a change in diet, but because of their inability to modify the ways they produce their food rapidly enough.

Today the world faces the same problem of finding enough to eat as was faced by the people of the Neanderthal age. The forces that have not been overcome in the millions of years of mankind's existence remain. The difference today is the question of time. More than anything else, the rapidity of population growth has led to the current crises in nutrition.

Unquestionably, population is rising, and quickly. The total human population was about 1.5 billion in 1900, about 3 billion in 1970, and will probably double again by the year 2000.

Malthus was the first to define the relationship between rapid population growth and food needs. We can restate his thesis in terms of caloric availability, which in turn tells us the upper limit of the human population that can be supported. Under the assumption that the agricultural technologies used in the U.S., for example, could be adapted to and fully utilized by developing areas of the world (an obvious overestimate of the capacity for human change), and that the dietary levels of the 1970s would be maintained, A. A. Altchul has calculated that a maximum world population of 7.2 billion could be sustained. This level of population would be reached by the year 2020. By then, according to the Malthusian view, population growth may be checked by warfare, pestilence, or starvation and famine.

This view was modified by Heinz von Foerester in a well publicized report that argued that such increases in population density would push mankind to the edge of existence, and that all of the technological resources at mankind's command could barely keep him from toppling over the edge. But this neomalthusean resurgence fails, just as the original predictions of Malthus failed. These forecasters could not predict the dramatic technological changes that occurred after their analyses, although Parson Malthus himself suggested that technology might modify his conclusions. Such events, depending on intuition and creativity, are only predictable in their randomness and in the fact of their occurrrence. Thus, von Foerester could not predict in 1960 the extent of change in new cereal technology brought about by the "Green Revolution" in the development of higher yielding varieties of wheat and rice. More importantly, he could not have predicted the increased nutritive value of some of these new strains. For that matter, can we today predict the impact of new areas in genetic research using recombinant techniques, or the impact of new, nonagriculturally based technologies for food production?

But, while use of fermentation and chemical synthesis to produce calories, protein and other nutrients has been described in exhausting detail, the existence of the technology does not provide a basis for understanding how much they can be used to actually alleviate hunger.

Eating to Satisfy One's Self

It has become overwhelmingly evident to nutritionists in recent years that people eat to satisfy themselves, and not to please the nutritionist, planner, or technologist. Palatability and emotional satisfaction are by far of greater importance to the consumer; nutritional benefit is often of secondary concern.

Yet even in the area of nutrition, the information needed to predict future food requirements, or to determine accurately the current nutritional state of populations, is not available. Classical approaches to these problems are so complex and time-consuming that they can only tell where we have been, not where we are going. Thus, the Ten State Nutrition Survey in the U.S. took three years to complete and several more to analyze. Similar studies of Latin American nutrition by the Pan American Health Organization have been in progress for more than ten years and are still not complete. A more rapid but less precise approach is based upon the estimation of nutritional need for various segments of populations in different regions of the world; these come from estimating population and demographic shifts, multiplying, and deriving a number which attempts to define future needs. This attempt suffers from several major difficulties. Standard values are, after all, averages or variations of an average; these studies are often based on non-physiological standards; and the need for more specific data and more specific evaluation methods adds to the time delay. Most importantly, none of these models attempts to incorporate the concept of dynamic change in what people actually eat.

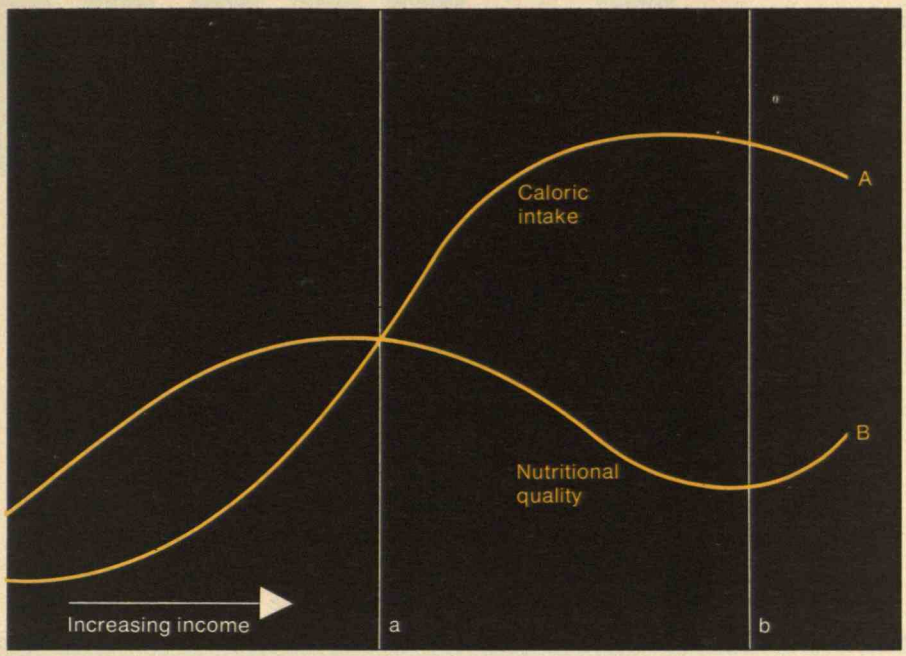
Clearly, the exponential rise in world population carries within it the seeds for political and social disaster of enormous magnitude. The prevention of this problem requires planning of food production and allocation of resources directed towards the most efficient solution of the problem. To do this, we would need a prediction model which permits reasonable estimates not only of nutritional need in terms of total nutrient production, but also in terms of the foods that people will eat and want. In other words, the optimal prediction must take into account preference as well as demand. As Margaret Mead said, "We should not ask how do you change food habits, but rather how food habits change."

In the past food patterns changed slowly. Today these changes are occurring at an enormously increasing rate. One way of demonstrating the rapidity of such changes is by estimating the time in which the use of a new food or technology becomes widespread. Thus for such ancient techniques as smoking, fermentation, and the use of spices the time span of general acceptance could be calculated in terms of centuries. The introduction of heat-processing of foods occurred over decades; today, a new additive or formulated product may be in general use within a few years. While it is useful to understand past actions, analyzing such trends in terms of general food groups does not necessarily lead to the prediction of future food needs, however. For example, in 1963 in several European countries there appeared a trend towards decreasing use of cereals and starchy materials and increasing use of meat and sugar, a trend that has continued until recently. While such analyses are useful, they are by nature empirical and retrospective. A useful kinetic model for predicting food needs would require more understanding of the factors modifying these choices.

The role of custom and culture, the availability of foods and fuels, and the role of status in food selection cannot be ignored. Food does more than fuel the body: it is used to maintain interpersonal relations, to cope with emotional stress, to reward or punish, and perhaps most importantly to maintain status. In general, these factors may be conveniently grouped under the heading of "cuisine." While cuisines differ, they do all seem to evolve towards a point where maximum nutrition is obtained in the context of local conditions. To put it somewhat differently, individuals tend to make bad nutritional decisions; successful societies make good ones. Thus the quick frying of Chinese and Italian cuisine was based on a lack of fuel, while the slow stewing and roasting of French cooking could exist because of an abundance of wood. The results were a maintenance of nutritional value, in the former case as a result of quick cooking and in the latter, by the conservation and consumption of the cooking liquid itself. Thus an elegant balance develops between good nutrition and good taste.

Nutritional problems result when the cuisine does not evolve as rapidly as the needs of the population using it. Then such customs cause nutritional status to decline and create a barrier to good health. Recognizing this could permit development of strategies to cause more rapid evolution of such cuisines or suggest appropriate points of intervention.

Income also plays a significant role in food selection. Increasing income generally results in a decrease in vegetable fat and protein, reflecting a decrease in consumption of cereals. In contrast, increasing income also results in increases in total fat, calories, sugar and animal proteins. In addition, the consumption of so-called "stress foods"



The postulated relationship between caloric intake and nutritional quality as income rises. The lines cross (A) after survival-related pressures cease to dominate the food selection process. At (B) it is possible that long-term consideration of future health becomes important. At this point most desires can be satisfied, and nutrition education can exert an effect.

such as sucrose and snack foods (foods that are usually more expensive in per-unit nutrients) also increase.

Not only an increase in caloric intake but, more importantly, a reduction in the nutritional quality of the diet result from increasing income. Diet, it has been discovered (*above*), improves with income only until non-survival-related pressures begin to dominate the food selection process. At this point a new group of nutritional disorders emerge. These may be called the deficiencies of affluence: they include obesity, cardiovascular disease, stroke, hypertension, and several other diseases. The erosion of nutritional quality occurs in spite of the fact that nutrition education is most intense among these groups; it has been taught for more than 40 years in the U.S. and in other parts of the developed world. Since nutrition education supposedly trains individuals to consider the consequences of present action on future events, it is clear then that, at least for the major portion of the curve of affluence, the selection of food is not made with the long-range consequences of such choices in mind but rather with the view of satisfying a short-term desire.

The Metropolitan Smörgåsbord

While the role of cuisine and the influence of income on food selection is generally understood, until recently little attention has been paid to the food and nutritional problems engendered by urbanization. This process, one of the principle characteristics of modern times, can be traced to the rise of centralized citadels designed for mutual protection in the cultures of the Fertile Crescent. But true cities did not grow until the technology of food production improved to the point where a significant proportion of the population could be spared from the production of food. In Europe, this agricultural revolution grew upon three major advances: the moldboard plow, the development of the horse as a draught animal, and the improvement of crop rotation techniques, particularly by the use of legumes. (By fortunate coincidence, the adoption of legume crops to improve fertility of soil produced not only more food but also food of greater nutritional quality.)

Since most who sought the cities were peasant farmers, the towns long remained extensions of the countryside. As population increased and occupations unconnected with farming developed, the towns became more dependent on food grown and transported to the town specifically for that purpose. Ultimately, every great city had its market, controlled by the crown (and often the church), and operated by great merchant guilds. In the end, the nature of the food produced and available for sale was determined by these groups whose decisions were based largely on profit or hope of profit, rather than the needs of the public.

Yet even under these conditions the food preferences of the individuals determined to some extent what they would eat. For example, the English peasants, despite an increase in sheep herding by the 15th century, had given up this traditional source of dairy products and become dependent upon beef because they had come to prefer the flavor. In other words, the peasant not only insisted on

	Quantities of food consumed (kg./yr.)			
	Chad		Japan	
	Urban	Rural	Urban	Rural
Cereal	124.8	169.7	150	168
Starchy roots	42.2	32.0	14.9	21.9
Sugar	4.2	0.3	5.1	5.5
Legumes and nuts	29.7	30.3	25.5	24.8
Vegetables and fruits	12.5	24.8	106.9	100.7
Meat and fish	45.4	19.3	41.2	33.9
Dairy products	1.4	4.0	20.4	9.5
Fats	17.9	32.1	13.3	2.6

A comparison of the quantities of different types of foods consumed in urban and rural communities in Chad and Japan. The more affluent, socially oriented city dwellers prefer to eat more animal protein (meat, fish, and eggs) than do farmers and villagers. Among Chad's rural people, herdsmen predominate; thus the rural consumption of fats and dairy products is high. Japan's high consumption of dairy products and fats among urban dwellers demonstrates their tendency to ape the diets of the affluent western world. The reduction in cereal consumption among urban Japanese is slight but significant: 20 per cent of this total is wheat, a western grain; wheat represents only 4 per cent of the cereals consumed in rural areas. (These data were adapted from deNigris, *F.A.O. Monthly Bulletin of Agricultural Economics and Statistics*, 22:1, 1973.)

having enough food to eat but, more importantly, food of a kind he found to be preferable. Centralized markets, the establishment of a dynamic center where people of many cultures could gather, and the development of an effective communication system combined to give townsfolk a diet in which new foods could be tasted and accepted rapidly. The food selection and the diet of city dwellers differed significantly from that of those of the countryside. Too, these diets changed more rapidly than those in rural areas.

By 1960, about one-third of the world's population lived in urban communities. By the year 2000, more than half of the people of the world will live in cities. In the developed world, the urban population will reach 80 per cent of the total and will approach 50 per cent in the developing areas.

Even though better communications and improved marketing facilities offer a greater possibility for improved diets, people's nutrition may actually deteriorate as a result of urban migration, particularly for people at the low income level. The general trend of urbanization is a decrease in caloric intake and an increase in the proportion of protein from animal sources. Since the cost of such protein is greater than the cost of cereal proteins consumed by rural communities, the amount actually consumed becomes a function of income. Thus Chad, with a very low real dollar per capita income, shows the same pattern as Japan, a country with a higher income per capita, but a lower total protein intake among urban dwellers. In addition, an increase in consumption of sugar, soft drinks, alcohol and expensive snack foods of lower nutritional value than traditional cereals and beverages often accompany urbanization (*see chart at left*). In other words, even at low income, the tendency is for urban dwellers to approximate the diets of more affluent segments of society, such as those in the U.S., regardless of income.

This pattern and low income limit the amount of protective foods (foods of high nutritional value and density) that can be purchased, resulting in a unique pattern of nutritional disorders: in this context we find in urban areas deficiencies of protein, calories, vitamin A, and thiamine; this is in contrast to the calorie, iron, and vitamin C deficiency that may be found in rural areas. A survey by Institute of Nutrition of Central America and Panama in 1970 reported similar changes in food consumption patterns between towns and countryside in Central America. Consumption of cereals, particularly corn, was higher in rural areas, while wheat bread was preferred in the towns. Meat, fish, eggs, milk, fruit, and vegetables were consumed to a greater extent in the cities. Calorie consumption was lower in the rural areas, emphasizing again the serious nature of food shortage in rural Central America.

Household expenditures also reflect the differences in urban and rural areas. In the country, about 50 per cent of food consumed was home-produced. Only 10 per cent was produced at home in the city, and the rest spent on foods obtained by purchase and by meals away from home.

This latter trend is also significant. Public kitchens have been a facet of city life almost since the founding of the city. They shaped food preferences in the Middle Ages, as places where new and unusual foods and cuisines could be sampled without immediate reeducation of the family cook. Consider, for example, the role of the Chinese restaurant in introducing new foods and food shifts to modern Western society. In the U.S., the popularity of this cuisine is legend and the U.S. has become a country of ex-

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How a Record 2,300 of M.I.T.'s Most Faithful Rekindled Friendships and Loyalty

It used to be called Alumni Day. But now it's Technology Day, to proclaim the many different dimensions in which its visitors are expected to renew their ties to M.I.T.:

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- ☐ Their professional goals served by M.I.T. classrooms and laboratories.
- ☐ Their commitment for support of the Institute and its service.

The program for Technology Day 1978 on June 8 and 9 catered to all these expectations, and they could hardly have been unfulfilled for any of the 2,300 alumni and their guests who attended. It was a record crowd, taxing the capacity of Symphony Hall for the Boston Pops and Rockwell Cage for the annual luncheon.

Those who returned ranged in age from the Class of 1908 (Franklin Towle and Harold S. Osborne, whose doctorate was the first given in the field of electrical engineering at M.I.T.) to the Class of 1978, whose President spoke at the annual luncheon. The faithful came from as far as Japan (Shikao Ikehara, '28, and Shinichi Ichimura, '53) and Europe (Hector E. Hagedorn, '28, Spain, and John G. Houpis, '28, and Alex G. Tsongas, '28, Greece).

Support for the Institute was unquestioned. Gifts totalling over $2 million from the three principal reunion classes (1928, 1938, and 1953) were announced at the annual luncheon *(see page A3)*, and Alumni Fund giving was reported at over $4 million for 1977-78.

But friendship came first.

In addition to 13 class reunions held in full or part on the campus, 12 schools and departments arranged open houses on June 8. By 8 p.m. that evening, when Arthur Fiedler — proudly wearing his cardinal blazer of the Class of 1917 (he wore out his first M.I.T. blazer, a gift of the Class of 1922,

For nearly a week everyone at M.I.T. had been cheering the 50-year Class of 1928 for its spirit, devotion, and stamina during an unprecedented six-day reunion. Then on Technology Day the tables were turned, and Peter H. Kirwin, '28, led his classmates in a cheer for M.I.T. as James Donovan, President of the Class, gave President Jerome B. Wiesner a reunion gift of $1.225 million. (Photo: Calvin Campbell)

Three aspects of renewal at Technology Day — friendship, support, and learning — celebrated in three pictures. At the top, President Jerome B. Wiesner greets two members of the Class of 1908, back for their 70th reunion: Franklin T. Towle (left) and Harold S. Osborne. Above, Kenneth Rosett, '42, is introduced at the 1978 Technology Day even as he began planning for the 1979 celebration, for which he is Chairman. Opposite, Professor Alan V. Oppenheim, '59, hosts queries on his description of how computers of the future (and some of the present) read, talk, and even sing for their owners.

six years ago) — came to the Boston Pops podium in Symphony Hall before a sell-out all-M.I.T. audience, the conversation was incessant; even the Orchestra's expert crowd-shusher in the violin section had trouble making way for the Verdi, Bach, Grieg, Gershwin, and others.

Later, conversations resumed among alumni and students in the living groups where every empty room was claimed for Technology Day guests by Joseph J. Martori, Director for Course and Class Programs.

Conversations with Computers

The computer took center stage on June 9, when Walter A. Rosenblith, Provost, presented a sampling of M.I.T. research and teaching by five members of the faculty.

Professor Richard C. Larson, '65, Director of the Operations Research Center, made a convincing case for computer-based services to help solve current urban problems. Among his proposals:

☐ Automatic vehicle locations systems, so that dispatchers can send the nearest available help to the scene of every emergency.

☐ Automatic bus locater systems, to help drivers maintain proper intervals between the buses ahead and behind them.

☐ Methods of operations research applied to urban needs, so that services and demand are more nearly matched. For example, said Professor Larson, the rate of incoming calls for police or fire departments varies with the hour of day and day of the week; but few cities correspondingly adjust the staffing of their dispatch services.

A few years ago, one could hardly imagine having a chat with a computer. But today computers can listen and understand, talk back, and even sing for us; and Professor Alan V. Oppenheim, '59, Cecil H. Green Professor of Electrical Engineering, made it happen. He explained how the human vocal system is replicated in computers by filters and electronic pulses to

Where Are the Hearts of Alumni?
A $6 Million Answer on Technology Day

Over $6 million in gifts from alumni — "an exciting demonstration of pride and love for M.I.T.," said President Jerome B. Wiesner — were reported for 1977-78 at the Technology Day luncheon on June 9.

Four classes made special contributions to this total:

☐ The Class of 1978, graduated just five days before (*see June/July, pp. A1-A7*), re-established the tradition of a senior class gift with a check for $850. It resulted from contributions by more than 25 per cent of the Class seeking "to make M.I.T. a more positive experience for the undergraduates," said James M. Bidigare, Jr., Class President; and 1,250 alumni at the luncheon applauded this evidence of a renewed spirit of loyalty and friendship for alma mater among the newest members of the Alumni Association.

☐ After 25 years in which to "reflect and take stock, measuring themselves and M.I.T.," said Richard P. Simmons, Reunion Gift Chairman, the Class of 1953 came down firmly on the side of the Institute: a reunion gift of $244,000 from 56 per cent of the Class, the highest participation in a 25-year gift in M.I.T. history.

☐ The 40-year Class of 1938 made its gift — $606,851 from 65 per cent of its members — a tribute to Mrs. Margaret Hutchinson Compton, the wife of the Institute's ninth President, "for all she has done and all she represents." It will be used to support the Gallery named in Mrs. Compton's honor in the Alumni Center. Haskell R. Gordon, thanking his classmates as their Reunion Gift Chairman, said it was "by any standard the most remarkable loyalty I've ever run across."

☐ When it came his turn, James Donovan, President and Reunion Gift Chairman of the Class of 1928, taxes typically eloquent: for 50 years the Class has been indebted to the Institute for education and fellowship, and now for four days it had enjoyed the Institute's generous hospitality. When he and his 150 classmates arrived on the campus on June 6, the Reunion Gift stood at something over $800,000. After four days of good fellowship (and hard work), Mr. Donovan announced on Technology Day a total of $1.225 million; in addition, he said, 24 members of the Class were known to have made plans for future giving, including bequests, with a present value in excess of $1.6 million.

All three reunion gifts represented total giving to M.I.T. by members of the classes during the five years preceding the reunions.

Norman B. Leventhal, '38, outgoing President of the Alumni Association, had more good news from the alumni for Dr. Wiesner: The 1978 Alumni Fund will total more than $4.5 million from over 21,000 contributors, probably topping previous records on both counts.

Of that total, just over $1.1 million represents pledges and payments to the "Building 10 Project" — the plan for a refurbished Room 10-250 and a new Alumni Center in Building 10. And that figure includes some 186 gifts of $2,000 or more whose donors are credited with "buying" chairs in the new Huntington Hall. At least 180 plaques are now in place on chairs in the new lecture hall to commemorate such gifts.

President Wiesner said this outpouring of resources has special meaning because it results from the continuing "efforts and caring of thousands of alumni." Such enthusiam, he said, will stimulate confidence in and support of M.I.T. thoughout the world. And Dr. Wiesner pledged a responsive concern for alumni and their interests. He hopes for new programs "to challenge alumni in the ongoing work of M.I.T., stimulating their interest in participation and even leadership."

Joe F. Moore Is President; but Can He Outrun His Predecessor?

Being the founder of his company, Joe F. Moore, '52, has never had the experience of a former president looking over his shoulder.

He will this year, though, and he's not sure he can live up to his predecessor's record and expectations, he told the Technology Day luncheon audience upon being introduced by Norman B. Leventhal, '38, President of the M.I.T. Alumni Association. Mr. Moore, who as President of Bonner and Moore Associates, Inc., in Houston heads a leading international consulting firm on oil resource management, is succeeding Mr. Leventhal as President of the Alumni Association until July 1, 1979.

Mr. Moore is well prepared for the assignment, having been a member of the Board of Directors since July, 1975, Vice President in 1977-78, and last year active in a study that is resulting in the installation of new software systems for managing alumni records and other administrative systems at M.I.T. Mr. Moore won the Bronze Beaver, the Association's highest award for service to M.I.T. and its alumni, in 1976.

Other new officers for 1978-79, whose election was announced on Technology Day by Mr. Leventhal, include Harl P. Aldrich, Jr., '47, Charles K. Holmes, Jr., '49, and George M. Keller, '48, Vice Presidents; and Marvin C. Grossman, '51, Emily V. Wade, '45, S. James Goldstein, '46, and Robert F. Calman, S.M. '67, Directors.

The 1979 Selection Committee, chosen in a national ballot during the spring, includes Dorothy G. Levinson, '57, John W. Barriger IV, '49, and Mr. Holmes; they'll choose nominees for vacancies to occur among officers and directors of the Association in July, 1979.

provide synethetic speech; and then he pulled a family of "electronic rabbits" out of his hat to demonstrate the countless applications of speech synthesis:

☐ A computer using a California-based program listened to a series of figures read to it in English and in French and gave Professor Oppenheim the correct totals.

☐ A Bell Telephone Laboratories program can turn a computer into a "talking machine": when words are typed into the computer's keyboard, the computer can respond with a display of the sound spectrum of the same words in spoken form — synthetic speech. Then Professor Oppenheim showed a computer which could steal the show from its master by giving a little speech of its own — in somewhat slurred but very understandable English — and later by singing a little song.

Computers may one day be helpful when it comes to geography, too. Though his demonstrations were frustrated by equipment that didn't quite do what it was supposed to do, Nicholas P. Negroponte, '66, Associate Professor of Architecture who heads the Architecture Machine Group, showed with a somewhat cloudy crystal ball how a computer can deal with three-dimensional space just as humans do: you find something on your desk because you remember where (not what) it is, he said; "we tend to remember chunks of information spatially."

If computers can be programmed to use geographical coordinates in the same way, said Professor Negroponte, they will help designers deal with space and the rest of us mortals to keep our ideas in better spatial array.

Computers as Diagnosticians

What does all this mean for the relationships between computers and people, today and in the future?

It's already a charged relationship, said Sherry R. Turkle, Assistant Professor of Sociology who's a member of the Laboratory for Computer Science; "people have stronger feelings about computers than they know, or like to admit," she said. Through research on the relationship, she concludes that these strong feelings stem from two major social unknowns: people fear that computers may change something about the way people reason and think; and people fear that computers may soon come to have minds of their own.

"These reactions betray our innermost concerns about maintaining the line between the human and the artificial," argued Professor Turkel. They appear not only among people who know little about the field. The same concerns actually are shared by engineers in the computer field — "a strong, broad cultural preoccupation," said Professor Turkle. But it's also true that the computer "is being blamed as an easy target for social problems that go far beyond it; it has become a metaphor, an easy way to avoid facing the political and social issues that lie underneath, with which we are terribly uncomfortable.

"The computer might help us to diagnose just the very things about our society and about ourselves to which we should give the greatest attention," said Professor Turkle.

A Record 4,000 Overflow the Campus for Reunions; You Name It, They Did It

Alumni reunions are bittersweet times — a curious admixture of uncertainty, nostalgia, exhilaration, warmth, and finally concern . . .

. . . Will I find anyone I like, anyone whose friendship I'll cherish — or even desire — now that five, ten, fifteen years are passed?

. . . How will I "stack up" against my classmates?

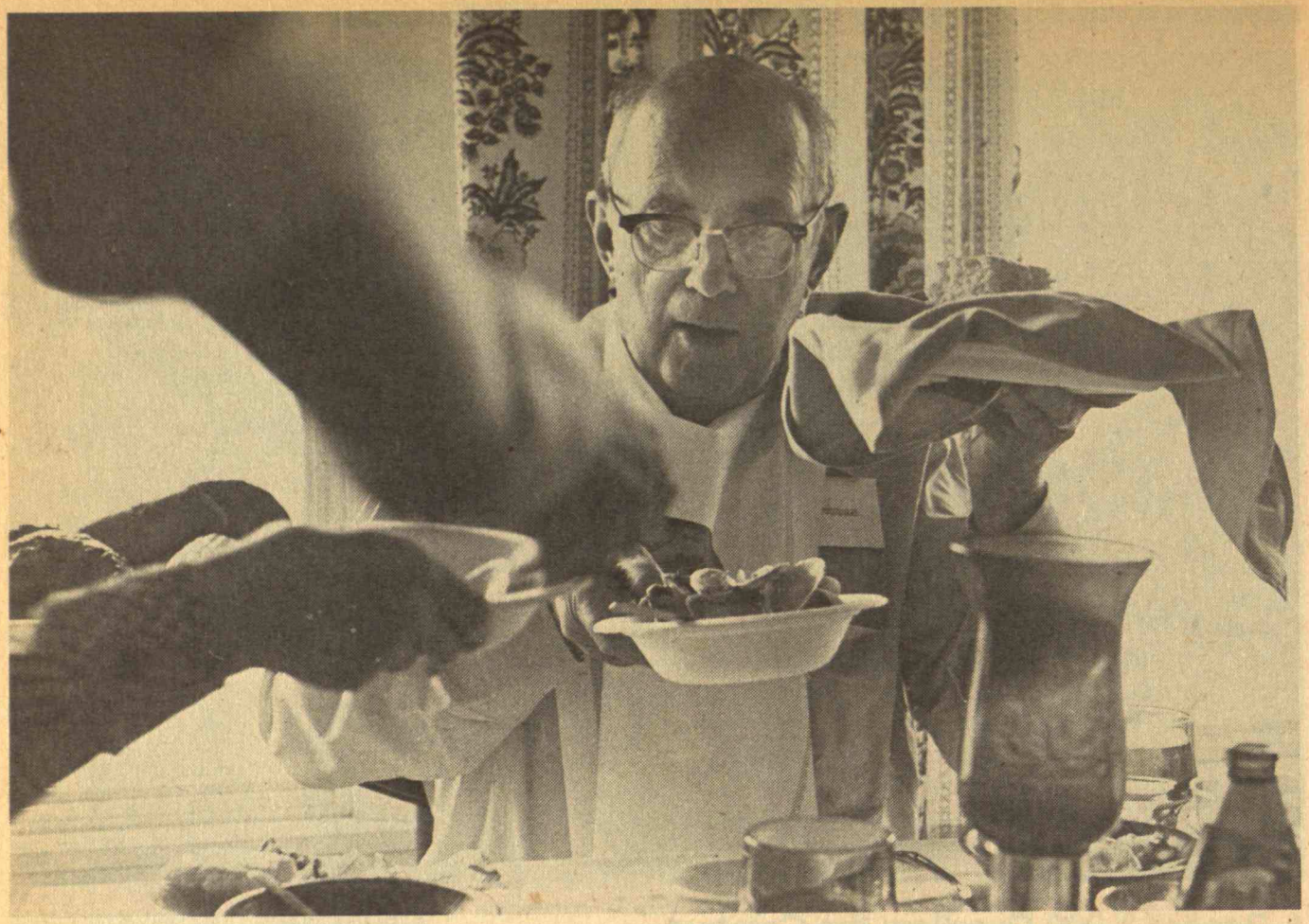
. . . Will there really be joy in returning to this campus which meant so much toil and heartache — as well as the fun of living and growing?

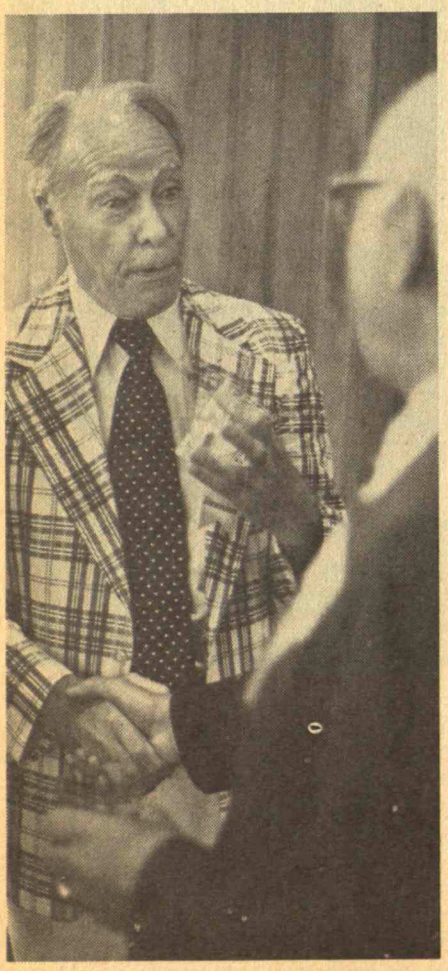
. . . Will there be anguish — more than it's worth — for hopes and events that never materialized, for friends no longer here, for those who bear afflctions that I do not — yet — share?

. . . And five years hence, dare we hope to repeat the joyous times of this reunion? Can the future be anything but anticlimax to this present? And what of my friends, old and new, who won't be back?

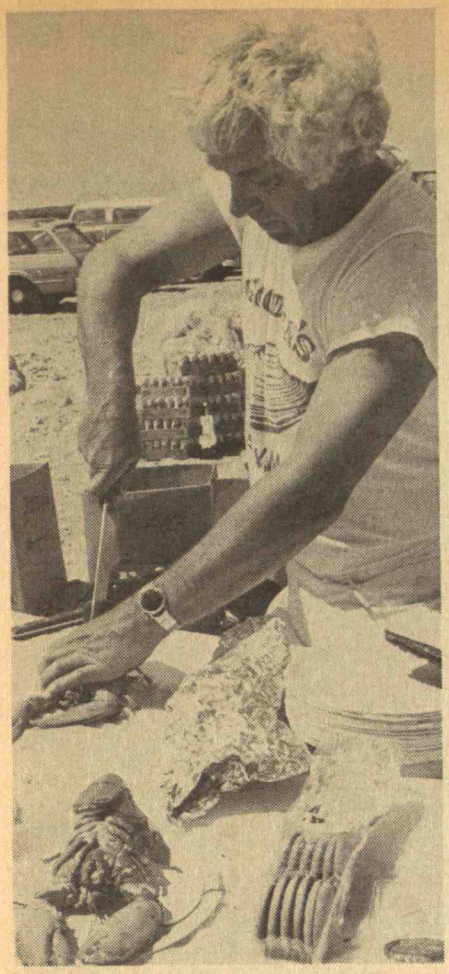
For more than 4,000 alumni and their families attending reunions between June 6 and 11, 1978, these questions all seemed to resolve themselves into an aura of deep-felt comraderie, even affection. From the Class of 1973 — still cynical about M.I.T. but beginning to admit of curiosity about themselves and the Institute — to the Class of 1913, whose five members were looking forward to a 70th reunion in 1983, it was the same: we had a wonderful time, we're coming back, and anyone who doesn't can't know what he's missing.

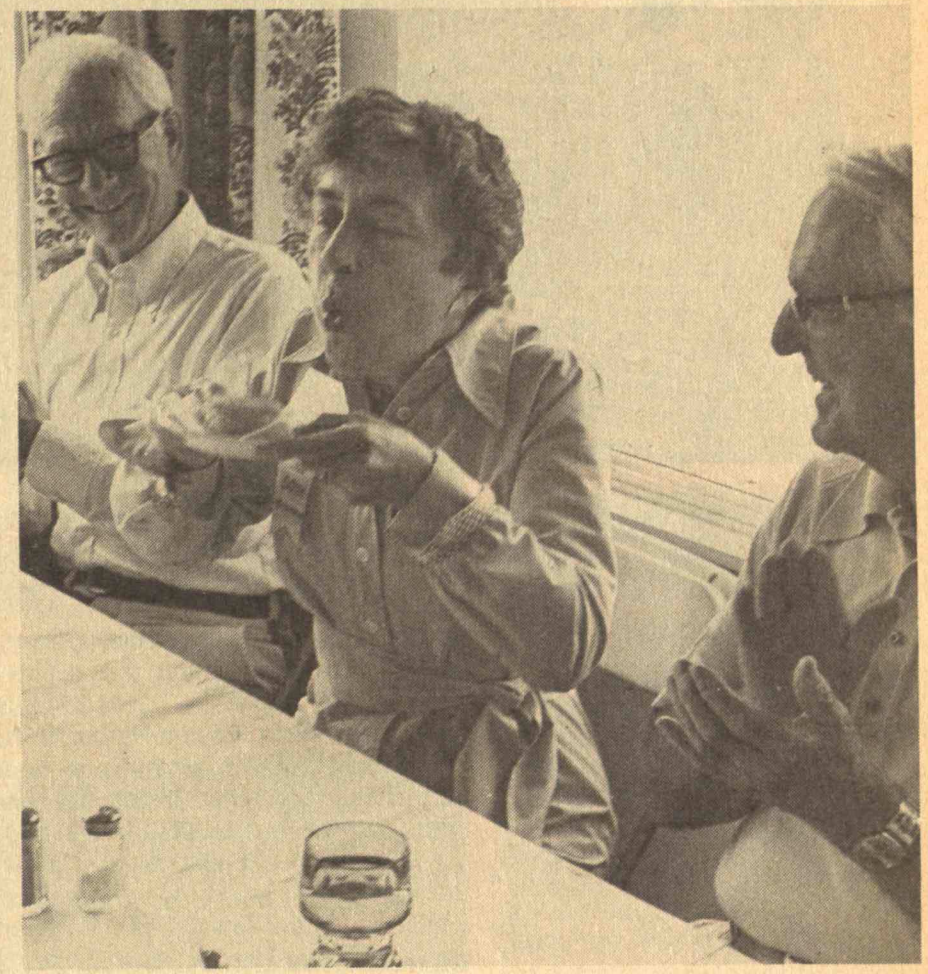
But it was the 50-year Class of 1928 that really made reunion history — for the second time. Twenty-five years ago the Class pioneered on-campus reunions, using Baker House as a base from which to explore Boston and the campus. This year no less than 258 classmates and their guests — by far a new record — came back to McCormick Hall for a six-day extravaganza that left everyone else breathless. There was dancing to the Scol-

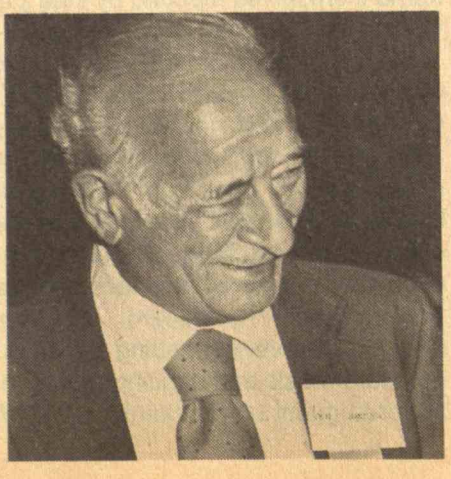




No pictures can do justice to the Class of 1928 and its unprecedented six-day nonstop reunion from June 5 to 10. For those who were there, these will refresh many memories; for those who weren't, they will give but a hint of the varied good times and high spirits. To give credit where it's due, the lobster-eater at the top of this page is James Donovan, President of the Class who was its Reunion Gift Chairman; and the two in the foreground of the group picture at the Corinthian Yacht Club are Florence and Ralph Smith, Co-Chairmen of the Reunion. (Photos: Gordon R. Haff, '81)







For its tenth reunion, the Class of 1968 went to Barnstable Beach (a clambake on June 10) and Boston Harbor (a sunset cruise on the "M.S. Bay State," same date). Aboard ship the new officers posed for Owen D. Franken, '68: Richard C. Lufkin, Vice President, with Mrs. Lufkin; Gail and Michael Marcus, Co-Secretaries; and Jay T. Nichols, Jr., President, with his guest of the week-end.

lay Square Stompers, endless singing around hastily-procured pianos, pictures by Professor Harold E. Edgerton, Sc.D. '27, Arthur Fiedler and the Pops, a clambake at the Corinthian Yacht Club in Marblehead, a tour of M.I.T. Historical Collections, a report on M.I.T. nutritional work by Professor Robert Suskind, and a special opening of "Pompeii A.D. 79" at the Museum of Fine Arts. You name it, they did it — and were ready for more.

Three classes — 1953, 1943, and 1938, nearly 600 in all — went to Georges Island in Boston Harbor for a cool, sunlit day of games and exploring on June 10; and some 90 members of the Class of 1968 spent the same day on Duxbury Beach. In both cases clambakes were the order of the day — that's 700 lobsters in three hours, and uncounted gallons of beer.

Between Monday and the following Sunday chartered buses provided transportation for 211 trips — campus to Long Wharf, President's House to Hyatt, campus to Marblehead, Sonsesta to State Street Bank. . . . The buses were recruited from all over Eastern Massachusetts, and several drivers found themselves rescued by their passengers' familiarity with the streets of Boston and by-ways of M.I.T.

To make sure that everyone was mobile, Joseph J. Martori secured four wheelchairs for the five-day period — one from the M.I.T. infirmary and three from a commercial medical supply house. When the dust settled on June 12, Mr. Martori found he had one M.I.T. wheelchair, two commercial chairs, and one chair from the Museum of Fine Arts, where the 50-year-class had seen "Pompeii." It was among the easier post-reunion problems to iron out, but it left Mr. Martori scratching his head in amazement: "They wouldn't even stay in their wheelchairs," he says.

Francis H. Achard, '13, attending his 65th reunion, found his classmates' evening ending too soon. Down the corridor in McCormick Hall he heard music and dancing: it was the Class of 1943, where he became the honored guest of the evening. — *J.M.*

After 50 Years and Countless Services, She's an M.I.T. Alumna

It was a big week — one she'll never forget —for Florence Jope Smith.

Her association with M.I.T. began just 50 years ago; as Florence Clayton, she became engaged to the late Ralph T. Jope, then President of the Class of 1928, within a year after his graduation from M.I.T. Even then, Mr. Jope was firmly committed to M.I.T..; he started work for the Institute (as Business Manager of *Technology Review*) upon graduation, and she soon joined him in countless activities in Cambridge.

That chapter ended suddenly after 37 years, when Mr. Jope was struck down by a heart attack in 1965 while on M.I.T. business in New York.

Then — years later a new chapter began: Florence Clayton Jope became Florence Jope Smith, the wife of Walter J. Smith, Secretary of the Class of 1928. There was never a pause in Florence Jope Smith's commitment to her husbands' alma mater, nor is there yet. This year, during the week of June 5, she was Co-Chairman (with Walter Smith) of the record 50th reunion of the Class of 1928; she and her family were donors of a coaching launch — the "Ralph T. Jope I" — for the Pierce Boathouse; she was honored by the naming of a new women's eight-oared shell in her honor (a surprise); and — to the cheers of 1,250 alumni at the Technology Day luncheon — she was made an Honorary Member of the Alumni Association (another surprise).

Presenting her for Honorary Membership, Norman B. Leventhal, '38, President of the Alumni Association, told Florence Smith, "Your strong, consistent, dedicated hard work in support of the Class of 1928 and of M.I.T. . . . has been an inspiration to all with whom you have worked."

Responding, Mrs. Smith took little credit for herself. It couldn't have happened, she said, without "two wonderful husbands who appreciated all that M.I.T. has done for them." And at the Boat House, surrounded by children and grandchildren, she recalled the "three great joys" of her first husband, Ralph Jope: family, rowing, and M.I.T.

"I know he's here with all of us," she said.

The day may have belonged to Florence Jope Smith. But the biggest picture — and she would want it that way — shows her granddaughter, Beth McNamara. Beth was helping the family (left) christen a shell named in her grandmother's honor; earlier on Technology Day Mrs. Smith had been made an Honorary Member of the Alumni Association by Norman B. Leventhal, '38, its President (top right). (Photos: Owen D. Franken, '68, and Calvin Campbell)

Interviewed on television in Pittsburgh on June 15, Mrs. Margaret Wargo was almost speechless. She and John J. Wargo (left) had just been presented with a citation for "exemplary parenthood" from M.I.T., and if that was not enough their four sons — all M.I.T. alumni — had walked in unannounced from Cambridge and California to surprise them; Mr. Wargo was still shedding tears of excitement and emotion as this picture was taken. The four sons are (left to right): Robert, '78, Michael J., '73, J. David, 'S.M. '78, and John J., Jr., '70. John J. Wargo, Sr., has worked at U.S. Steel Corp.'s Clairton (Pa.) Works for 38 years; he was eligible for retirement two years ago but kept working to keep his sons in college; "Dad always told us, 'School comes first'," said Michael. (Photo: Wide World)

An "Exemplary Parenthood" Award to a Steelworker and His Wife: Four Sons Are Alumni

A week after Commencement — and just two days after *Technology Review*'s Commencement coverage (*see June/July, pp. A1-A7*) closed at our printer's — Michael J. Wargo, '73, walked into the M.I.T. News Office: Would it be of interest to know that he was one of four brothers to have studied at M.I.T., and that two of the four had received degrees from President Jerome B. Wiesner just the week before?

It would indeed, said Robert M. Byers, Director of the News Office; and the more he learned the more interested he became.

The result was a special recognition on June 15 in Pittsburgh to John J. (Sr.) and Margaret Wargo for "exemplary parenthood," presented by Henry Avery, '41, Chairman of the M.I.T. Educational Council in Pittsburgh, on behalf of the Board of Directors of the Alumni Association.

John J. Wargo (Sr.) operates Boiler House No. 2 at U.S. Steel Corp.'s Clairton (Pa.) Works, where he's been employed for 38 years. Both he and Mrs. Wargo are the children of Slovak immigrants. The family's association with M.I.T. began in 1966, when John J., Jr., entered in the Class of 1970, having been inspired to apply to the Institute by his high school teachers. Two years later he insisted that younger brother Michael ('73) should also come to Cambridge, and after that their course was obvious to David ('75) and Robert.

"We grew up in an area where coal barges, trains, heavy industry and engineering were close to us," Michael says. "We all did well in those kinds of courses."

All the brothers worked at a variety of jobs to "take as much of the load off Dad" as possible, Michael says.

The cost of the 24 years of undergraduate and graduate education the Wargos have received at M.I.T., based on a budget calculated for the average student, is more than $100,000. (This includes tuition, fees, room and board, books and suplies and incidental living expenses.)

About two-thirds of that estimated cost was offset by a package of financial aid from M.I.T. through various federally supported programs, and scholarship aid from the Commonwealth of Pennsylvania, the United Steelworkers of America, the National Merit Scholars program and the American Legion. The sons' own earnings during their school years and during summers plus the family contribution made up the difference.

Joining Mr. Avery and several other members of the M.I.T. Club of Pittsburgh in presenting the Alumni Association award, Constantine B. Simonides, Vice President of M.I.T., told Mr. and Mrs. Wargo at a small Pittsburgh ceremony, "The story of the Wargo family is living proof that any goal is attainable if there is vision and a sense of purpose backed by hard work and the support of a loving family. To be a successful mother or father

demands wisdom and understanding as well as hard work and sacrifice. It is obvious to me that the Wargos have these qualities in ample measure."

Then Mr. Simonides told the senior Wargos that he wanted them to meet some other alumni. Out came their four sons, who had been flown to Pittsburgh by the Alumni Association as a Father's Day surprise for their parents.

"I thought you were on Cape Cod," said Mrs. Wargo, tears in her eyes, as she saw Bob. There were lots of hugs and kisses — and more tears — as the four sons surrounded their parents and press and even television cameras clicked and whirred. — *J.M.*

The Need for Innovations In Training Innovators

Artists are born, not made. But good training has produced thousands of craftspeople whose creations, while fewer and less brilliant, have nevertheless advanced their arts.

Innovation is the same way: some people seem to be born innovators, just as some have inborn athletic prowess. But good teaching and practice can sharpen an innovator's skills, just as good coaching and exercise improve an athlete's performance.

It was to test this concept that the National Science Foundation in 1973 made grants for innovation centers at four institutions — Carnegie-Mellon, M.I.T., the University of Oregon, and the University of Utah. Now, that seed funding is ending, and the future of these four centers depends on their ability to command industrial grants and to generate profits from innovations spawned among their students.

But it turns out that successful young Fords and Carnegies are not produced by two-year academic programs, and none of the centers is yet self-sufficient. They have, in fact, experienced more than their share of business failures: the M.I.T. Innovation Center's venture into computer-based television games blossomed briefly but could not compete in the cut-throat world of large-scale manufacturing and merchandising; and a computer-based personal-alarm system devised at the Carnegie-Mellon Center for Entrepreneurial Development has failed in the marketplace with its finances still to be untangled.

It was to compare such experience, and to build enthusiasm for the innovation centers despite their mediocre financial returns, that Professor Li gathered his colleagues together with several hundred industrial and government experts at M.I.T. this spring. The mood was cautious: everyone was convinced of the key role of innovation in future American prosperity, and no one wanted to condemn any reasonable effort to foster it.

Bernard M. Gordon, President of Analogic Corp., ventured closer than anyone else to the cold-water faucet; innovation requires the kind of spirit that cannot be bred by university training, he said.

But Frank Press, Presidential Science Adviser who was the symposium's keynote speaker, had an answer to that. The innovation centers — attempts to institutionalize innovative creativity — are themselves innovations; and they have experienced some of the same kinds of growing pains that have in fact wiped out their fledgling enterprises.

Our problem now is to accept the reality of innovation in a modern, complex economy with mass marketing, costly market research, and intensive federal regulation. "I think we should all recognize that industrial innovation requires — as well as creates — institutional innovation," said Dr. Press. "Our technological advances require of us a new level of both management and imagination. We have to be better organized and more responsive to the need for change."

A "drawing with your eyes" machine in which you can draw images on a video screen by just moving your eyes (top) was one element in many active, performing sculptures by some 24 artists who are fellows at M.I.T.'s Center for Advanced Visual Studies. Joan Brigham (bottom) makes an adjustment. (Photos: top, Calvin Campbell; bottom, Jane Fuhring)

"Beast" Designed by Center for Advanced Visual Studies Artists on the Mall in Washington, D.C.

by Ross C. Anderson

On a grassy expanse of the Mall in Washington, D.C., not far from the Capitol building, there sits what seems to be a 144-foot long glass trough, filled with water and supported by an elaborate scaffolding of bright blue steel beams. Above it several long pipes and tubes are affixed atop one another, like the lines of a musical staff. Smaller instruments — mirrors, loudspeakers, lights, and other gadgets of no easily determinable purpose — are attached at various points; beside it three television screens are set within a small mound of earth. This structure, which has been alternately entertaining and puzzling onlookers since late June, is but the latest version of "Centerbeam," a multi-media performing sculpture designed and constructed by 20 resident artists at M.I.T.'s Center for Advanced Visual Studies. Originally exhibited last summer in Kassel, Germany, the piece has been altered and expanded for its present site.

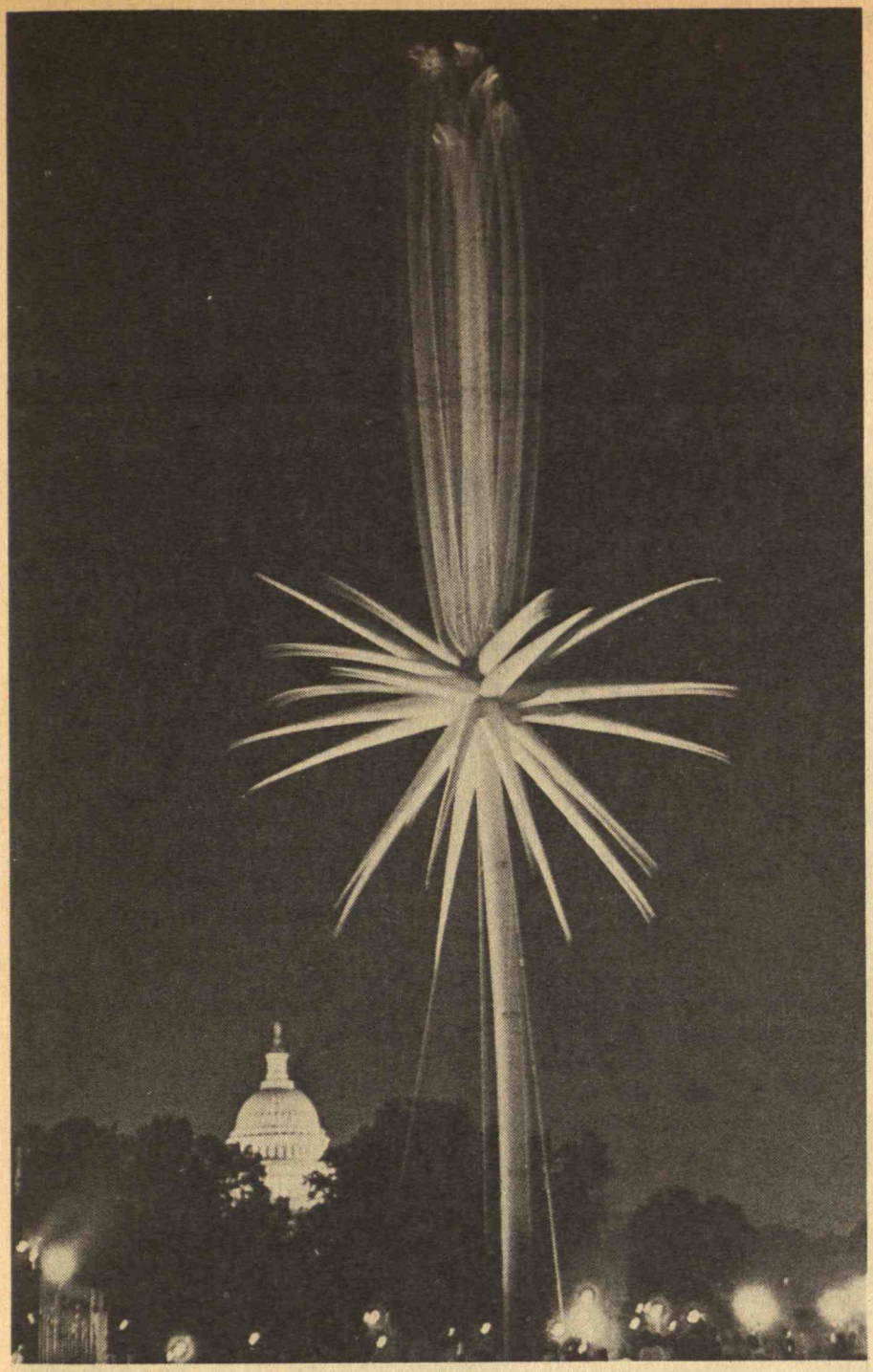
Center Director Otto Piene has described Centerbeam as a "beast," and the metaphor is apt. By day, the work is largely dormant, but at night it lurches reluctantly to life, coaxed and cajoled by the participating artists who hover continually around it. All will be quiet and motionless, and then a burst of steam will erupt from a pipe, music will sound, lights will flicker, pictures will appear on screens, and another Centerbeam performance will have begun.

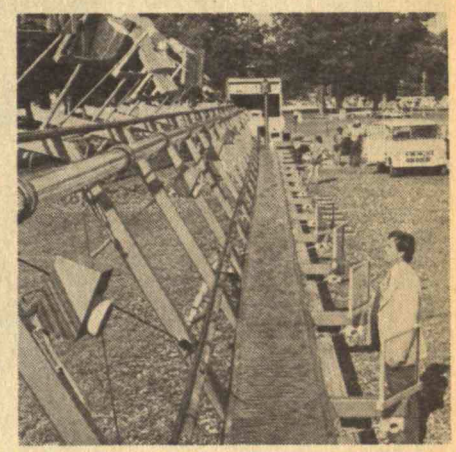
A different artist conceived each of the sculpture's special features. Among the most attractive are Harriet Casdin-Silver's glass-encased holograms, wherein multicolored images of forks are transmitted through sunlight during the day, and incandescent light in the evening. As the light source or spectator moves, the shapes of the forks are altered, and the colors change. More bizarre is Paul Matisse's "kalliroscopic white river," in which a white liquid bearing a disarming resemblance to semen is channelled down a long narrow platform. The spectator is invited to observe the sunlit patterns created by the gentle motion of the current, and to touch the river surface with his hands, thereby modifying its flow and altering the designs.

Otto Piene's personal contribution to the project are several inflatable sculptures which loom high over Centerbeam from time to time. These helium-filled structures come in a variety of shapes, including skyflowers such as an enormous but graceful black rose, and a bright red, many-tentacled sea anemone. Late in August, inflatable costumes will be used in theater productions performed on, around, and above Centerbeam. Live singers and musicians will interact with Centerbeam's light and sound imagery to produce such pieces as the "sky opera" *Icarus*, based on the classic story of the boy who flew too close to the sun.

The adaptation of Centerbeam to its new site has not been without difficulties, which range from leaks in various energy systems, to winds too brisk for inflatables, to the loss and alleged theft of the Centerbeam mascot, an amiable golden retriever. In its early stages, the most pressing problem was, however, that the Food and Drug administration prevented the artists from putting into effect one of Centerbeam's most dramatic features: the projection of laser beams through moving clouds of steam, and on to the wall of the Air and Space Museum next door. F.D.A. authorities were understandably wary; recently at a local rock concert uncontrolled shows of laser projections resulted in burned-out retinas for several unfortunate fans. However, a series of tests assured the officials that the intensity of the beams was so low as to be harmless; presently the mechanism is working as planned.

In considering Centerbeam as a whole, it is easy enough to describe how it looks, and what it does, but to actually decide what it is is far more challenging. When queried about its ultimate purpose, the artists agreed the





work was celebratory in nature, a means whereby technology customarily reserved for accomplishing tasks is set free solely for the purpose of sensual delight. To Lawry Burgess, who originated the concept of Centerbeam, the sculpture is "an attempt to find a basis for a humanizing attraction to the technology that surrounds us." But few artists chose to be that specific. To Otto Piene, the uncertainty of the work's conception, and the experimental, "run it up the flagpole" attitude prevalent amongst its creators, are the sculpture's most tantalizing attributes. "We have three months to find out what Centerbeam is, and what we are doing here," he stated recently.

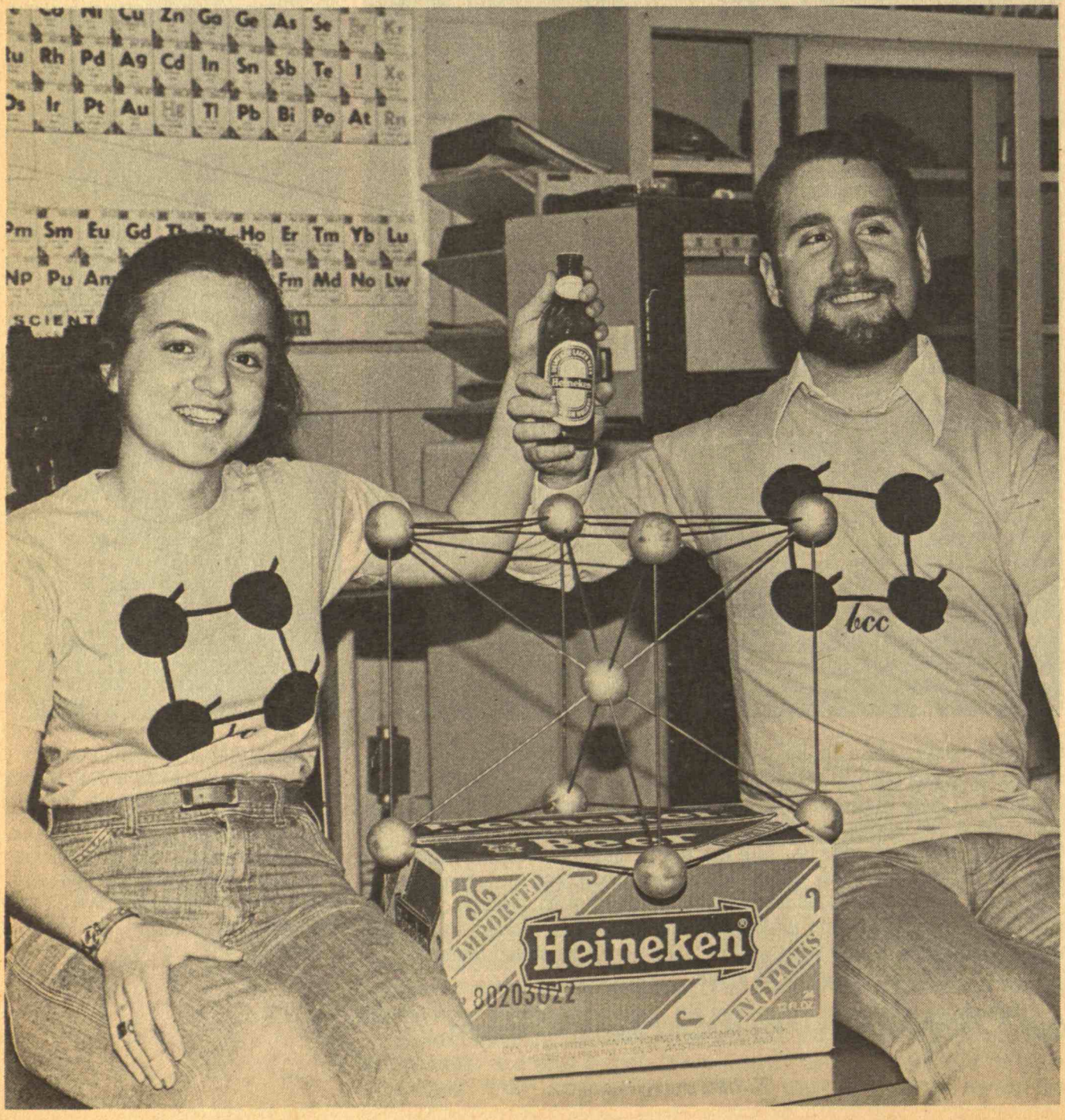
But he doesn't seem to be in any hurry.

Ross C. Anderson studied history of art at Princeton and Harvard.

An inflatable sculpture by Otto Piene, "Anemone," (left) is airborne to a height of 200 feet by helium-filled polyethylene tubes, tethered to the ground. Top: Mr. Piene prepares his sculpture; center: a performance of steam; bottom: a 144-foot long water prism. (Photos: top right and bottom right, Jane Fuhring; Calvin Campbell)

Under the Domes

It's called a "body-centered cube" — the design printed on those T-shirts — and it won a contest sponsored by the Student Materials Society for its originator, William N. Schaffner, '77, who's a graduate student in metallurgy. The idea was to gain publicity for the Department of Materials Science and Engineering and make money for the S.M.S. Why the Heineken? It was Mr. Schaffner's prize, which he generously shared with Jean Gregory, '79, President of S.M.S. (Photo: Steven L. Solnick, '81, from The Tech*)*



Umana: the Most Magnetic of Boston's "Magnet" Schools

The Mario Umana School of Science and Technology in East Boston, in whose development M.I.T. has been a partner (with Wentworth Institute and the Massachusetts Port Authority), is the jewel in the crown of the Boston School Department's "magnet" schools.

There were between 300 and 350 vacancies in the Umana School for the year just opening, and more than 1,800 students from throughout Boston applied to attend — the most popular by far of the 19 "magnet" schools in the system. The applicants were split almost equally by race — 893 blacks, 769 whites, and 155 other minorities, a distribution the Boston School Department calls "superb."

The 19 "magnet" schools were created as part of the court-ordered efforts to bring about desegregation in the Boston system; they are designed to serve students with specialized interests who come from throughout the city. Federal Judge Arthur Garrity asked Boston educational and public institutions and businesses to act as advisers and partners to the School Department in implementing the plan; to meet its responsibilities at the Umana School, M.I.T. named Stanley Russell to be Director of a Secondary Technical Education Program.

It's with Mr. Russell's help that Umana has developed the program which is so widely admired by Boston high school students. In 1977-78 Umana drew students from every school district in the city; only 20 per cent came from East Boston. That ratio will be about the same in 1978-79.

John R. Coakley of the Boston School Department credits Umana's popularity to several factors — an "aggressive" recruitment effort and the "harmonious atmosphere" created by Gustave Anglin, the School's Headmaster, and the "attractiveness" of the School's collaborators, M.I.T., Wentworth, and MassPort. There are curricula in aviation technology, electronics, computer science, medical technology, environmental science, and others.

Has Alexander Calder's "The Big Sail" grown smaller, like Alice in Wonderland? Not so; the photograph shows one of the sculptor's working models being installed on the plaza of the Center for Advanced Engineering Study (Building 9) on Massachusetts Avenue late last spring. It's the gift of Julius A. Stratton, '23, President Emeritus, and Mrs. Stratton — an important addition to a project of the Committee on the Visual Arts for encouraging the study of artists' creative processes. (Photo: Calvin Campbell)

Moving to Killian Court in 1979

Weather permitting, Commencement will return from Rockwell Cage to the tree-shaded greensward of Killian Court in 1979 — the first outdoor graduation at M.I.T. since 1927.

As graduating classes grow larger, Rockwell Cage seems to grow smaller and smaller. For this year, with its 4,200 seats to be distributed among 1,300 graduates, each member of the Class received a strictly-enforced allotment of two guests' tickets for Commencement; and a lively black market — with scalpers' prices — quickly developed.

Next year in Killian Court there will be 6,000 seats and additional standing room among the trees. A stage on the Building 10 steps will be the only construction; there will be no protective covering, and everyone concerned will be hoping for a repeat of the cool, sunny weather which came for 1978. (The Cage will be equipped as a rain location with seats but no elaborate stage such as now is built for Commencement, and some of the tickets issued for Commencement will be valid for Cage seating.)

On-the-Job Training in the Summer

Thirty-two M.I.T. engineering undergraduates will return to studies at M.I.T. this fall after spending the summer on work assignments at 12 companies. They're the first participants in the School of Engineering's Internship Program — a school-wide extension of the cooperative education plan which has been so successful as Course VI-A in electrical engineering.

Company representatives interviewed 221 students last March, and when the dust settled 67 undergraduates applied for places as interns; 32 were accepted. Professor Joseph M. Sussman, Ph.D. '68, Associate Dean of Engineering for Educational Programs, and John R. Martuccelli, Director of the Internship Program, will work during the coming year to sign up more companies, and then more students, as participants next year.

H. Jacoby

Policy Studies in the Energy Laboratory

Recognizing that our "energy problem" may be as much policy as technology, the M.I.T. Energy Laboratory has now established a Center for Energy Policy Research — in which industrial and public organizations are invited to become Associates — and named Henry D. Jacoby, an energy economist who is Professor of Management in the Sloan School of Management, to head it.

Professor David C. White, Director of the Energy Laboratory, says the Center is already making "significant progress in its mission of increasing the nation's capacity to make effective energy policy." It does this, he says, by "raising the quality of policy analysis and the level of public understanding of energy problems."

Already 18 organizations — 12 industrial firms, four public-interest groups, and two utilities — have joined the Center as Associates, and a primary objective is to increase that membership to include other sectors of society — labor, transportation, and finance, for examples.

Five subjects for research have top priority with Professor Jacoby:

- ☐ The dimensions of our domestic primary energy supplies; Professor Jacoby wants to integrate geologic and engineering information to produce better estimates of future supplies of oil, gas, coal, and uranium.
- ☐ The future of international energy markets — the demands for oil, uranium, and coal, and the response of the market in terms of trade and price formation.
- ☐ Better methods for forecasting long-run energy demand and the effects of conservation, including how prices, subsidies, taxes, and other controls might affect consumption.
- ☐ Innovation in energy technologies — how it should be fostered, and what should be the appropriate role of government.
- ☐ How energy markets relate to overall economic growth and development.

Professor Jacoby thinks the need for M.I.T.'s work in these fields is critical. He says studies that originate in industry or government are heavily discounted by political leaders and the public because of their sources. "There is an important contribution to be made by a strong policy study team . . . whose objectivity is unquestioned," he thinks. Funding of about $2 million annually is now available, including $400,000 from Associates of the Center for Energy Policy Research, and 13 faculty, 20 professionals, and 40 students are involved.

Professor Jacoby himself has been a member of the Sloan School faculty since 1973, when he received his doctorate in economics from Harvard; he has an undergraduate degree in mechanical engineering from the University of Texas, Austin.

An 18-day U.S. tour sponsored by the American Cancer Society for a scientific delegation from the Peoples Republic of China brought Wu Kuan-Yun (center) and Wu Min (right) to the Center for Cancer Research at M.I.T. late last spring. Dr. Kuan-Yun is a biochemist at the Chinese Academy of Medical Sciences, and Dr. Min works in cell biology in the Academy's Institute of Cancer Research. Their hostess in one of the Center's tissue culture rooms is Dyann F. Wirth, a graduate student in biology. (Photo: Calvin Campbell)

03

Well, happy classmates, I imagine you all on your feet, even if assisted by a cane like John.

Your rugged secretary is still active and prepares his own meals. I will be leaving soon to retire at my son John's open estate in Louisville, Ky. — **John J. A. Nolan**, Secretary-Treasurer, 13 Linden Ave., Somerville, Mass. 02143

12

I regret very much to report the death of **Charlie Webber** on March 29, 1978. I have no details; the last I heard from Charlie was a Christmas card on which he said that he was sorry not to attend our reunion but would be having a hernia operation at the time. . . . **Jerry Hunsaker** reports, "retired, age 91, inactive." But people around M.I.T. know that "inactive" is a relative term. . . . The latest from **Harold Brackett** states that he and his niece Eleanor Forbes have gone to their ancestral home in Maine, where they usually spend the summer. . . . **Jonny Noyes**, who has been in a nursing home for several months on account of his broken hip, expected to be out sometime in May. He is already planning another trip to Mexico and hopes to get to Maine again this summer. If Mexico is that good, surely some of the rest of us should be going there to check up on Jonny and see what it is all about.

Most of us have known **Wally Murray** for his world wide travels and experiences but have never known much about the real Wally, his abilities and accomplishments. Also we thought the phrase like "making a purse out of a sow's ear" applied to something which couldn't be done. A friend recently sent me a copy of the April issue of *Nucleus*, the monthly publication of the Northeastern Section of the American Chemical Society. Under the heading of Historical Notes, the magazine gives the low-down on a portion of Wally's past life. We learn that Wally did, indeed, make a purse from a sow's ear. He joined Arthur D. Little, Inc., in 1920, and quickly was given the task of doing something to dramatize the involvement of A.D.L. in the growing field of scientific fibers. He actually produced a purse from the sow's ear, and it is now on display at the Smithsonian Institution in Washington.

We are still short $450 for our 1912 Chair for the new Huntington Hall. How about cleaning this up? **Phil Dalrymple** is chairman of this project and would be happy to hear from you.

Your Secretary and his wife Julie recently returned from our postponed trip to Florida. On the way down we stopped off to have a little visit with Katherine and **Paul Tyler** at Holmes Beach. It was good to see them, and we had a nice visit. They are both well but, as with most of the rest of us, they have some problems. At the time of our visit they were in the process of building a new home in a nearby retirement village. This will eliminate the yard work and some of the other chores incident to their present home. — **Larry Cummings**, Secretary, R.R. #4, Connersville, Ind., 47331

13

It was a small but congenial group that met on June 8 to celebrate the 65th Reunion of the Class of 1913. Those present were **Francis H. Achard**, Maurine and **Allen Brewer**, **Walter Muther** and his daughter, Sally Lawton, and **Charlotte Sage**. **Warren Glancy** also joined them for Alumni Day Lunch on Friday. They enjoyed a cocktail party and dinner, followed by Tech Night at the Pops. Reportedly while the 1913 group was attempting to battle the crowd and board the bus a young man appeared, held back the crowd, and said they should "have the privilege of watching the '13ers get on the bus." We would like to thank the young man.

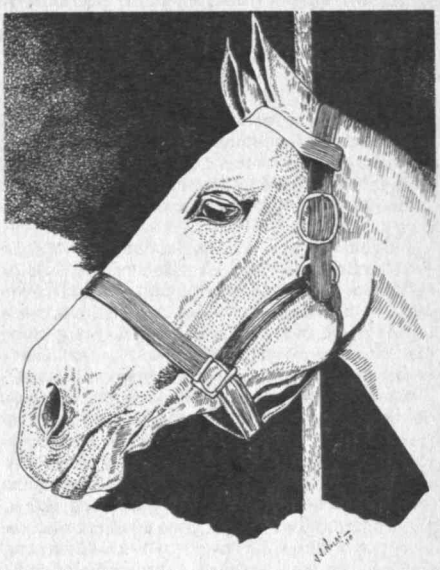
The group also held a class meeting at which the following officers were elected for the next five years: President, **Walter P. Muther**; Vice President, **Charlotte Sage**; Secretary/Treasurer, **G. Philip Capen**; Assistant, Rosalind Capen. **Frank Achard** will continue as Class Agent and member of the Alumni Council.

We voted to continue sending yearly bills for $2.00 dues. So watch your mail in the early fall and be prepared to send us news of yourself along with the dues.

The **Phil Capens** regret they were unable to attend the festivities. Phil had been in the hospital for over three weeks after a coronary spasm. He is doing fine now and getting stronger every day.

Our faithful correspondent and friend, **Allen Brewer**, wrote a poem about the 65th Reunion which we quote:

Now listen my brethren and mark ye well,
Of a Class with a story I'd like to tell.
'Tis Thirteen's reunion; sixty-five years ago,
They faced a stern world with hopes all aglow.
They offered their talents of Technology's skill
To build "better mousetraps," their ideals to fulfill.
As "frosh" they wore uniforms, dinky and blue,
For drill at the armory, just because they had to.
But with the chips down and a war job to fill,
They put in full time with a smile and a will.
They'd mass there on Roger's Steps, always with pride,
They climbed Walker's stairs without missing a stride.
Engineering A taught them the devious facts
Which shaped the designs of their later-day acts.
They sang the Stein Song at the Pops, unconfined,
Life at Tech was severe, but never a grind.
They won both their Field Days, worked with the Tech Show;
They lived their lives fully, their pep overflowed.
Some sought out the Boylston Street "Chapel" at times,
To study (?) agriculture via corn, hops and rye.



Famous horse by John Nolan, '03. Working for the government as a mechanical draftsman helped Mr. Nolan perfect the skills of fine detail and accuracy necessary for drawing this horse in 1938. It was done from a small photo of the winner of the Kentucky Derby. Having grown up around horses, Mr. Nolan still has fond memories of these fine animals. When asked his secret for a long healthy life, he replies, "Moderation is the key." Otherwise he leads a "regular" life.

Classmates and their guests meet at the Chatham Bars Inn for the 62nd Reunion of the Class of 1916. Front left to right: Don Webster, Francis Stern, Ralph Fletcher, Barney Gordon, Frances Duff, Paul Duff, Beatrice Binger, Walt Binger. Middle left to right: Majorie Webster, Gladys Stern, Sibyl Fletcher, Betty Crowell, Bruce Crowell. Back left to right: Jeremy Gordon, Nat Warshaw, Rose O'Brien, George Crowell.

We hope Thirteen's been a class to be proud,
All credit to Tech, those who've stood out in the crowd.
Technology gave us that inborn instinct,
How to plan, how to judge, how to love, how to think.
So now like the "Ancient Mariner" of old,
We ask you to stop, hear this story we've told.

William G. (Jack) Horsch reports, "Last December 29 was Gertrude's and my 60th. A family dinner party and a no-host dessert in our home attended by many church friends, plus many cards, made our anniversary a memorable one."

From **Charles Albert Smith** we hear, "I will be 90 next August and am of necessity retired (possible employers think that I must be very senile and therefore useless). I live with my wife Rose, who is 84, in Altadena, Calif., at the base of the San Gabriel Mts. Our hobby is gardening, thanking the good Lord for our over 60 years of companionship since our wedding in 1917, visiting with our two sons and wives, and our grandchildren, who all live within 100 miles of us."

We also have received notices of deaths of the following 1913ers: **Madison W. Christie**, **Halsey Elwell**, Dr. **Arthur W. Kenney**, **Malcolm Lewis**, **Joseph N. Paul**, **Gordon H. Robb**, **Kenneth A. Scott**, and Mrs. **Thomas A. O'Reilly**.

Well, think this about covers the news of the Class of 1913. Hope you will all enjoy a pleasant summer — **G. Philip Capen**, Secretary and Treasurer; Rosalind Capen, Assistant Secretary, Granite Point Rd, Biddeford, Maine 04005

14

Frank Atwood thoughtfully telephoned me on Memorial Day to make sure that I wasn't expecting him to be in Cambridge for Technology Day in June. (I didn't go either.) Frank has sold his hotel on Martha's Vineyard but is still living in his house in Edgartown. Except for some arthritis, he is in good health; his wife had just come home from a hospital and was continuing her recovery. His children and grandchildren, who mostly live quite far away, are all doing well; and there are four great-grandchildren.

An invitation from **Ros Barratt** in June made it possible for me to have a leisurely lunch with him and **Bert Hadley**, his weekend guest, under a canopy on the beach of a club near Ros's home in Southport, Conn. Bert had lived in Southport before he retired. He had driven down from his home in Middlebury, Vt., a few days before to attend a meeting in Bridgeport and to visit several old friends. To be with those two classmates again made a great day for me.

A letter from **Harold Mayer** in May tells of a unique kindness he's been doing. "Recently I met a young fellow at the library. He is about 25 years old and originally from Germany. He must have come over here when he was very young, as he speaks German better than I do and also speaks English. But he cannot read German — so I am helping him. He is a charming fellow."

Thomas W. Sheehan died at his home in Branford, Conn., on April 28, at the age of 90. He was a Course I man and was with us in all four years. For 50 years, until his retirement in 1958, he was City Engineer of Malden, his native town. Tom is survived by his sister, Mrs. Jane Killian, of Branford, and by several nieces and nephews. — **Charles H. Chatfield**, Secretary, 177 Steele Rd., West Hartford, Conn. 06119

15

Hello everybody! Hobbling around on a cane is much better than rolling in a wheel chair. So, finally, I've got up enough "steam" to try to catch up on our class notes. Joyce Brado has done an excellent job for us on the annual Alumni Fund, with a total of over 60 per cent contributions from our class, the sixth largest total of all classes. Thank you all and congratulations to Joyce who has helped us so much.

In December, 1978, **Ray Stringfield** had a bad stroke and has been in a convalescing home ever since. Our sympathy to you Ray. . . . **Phil Alger**'s grandson, Monty, received a master's degree in June at M.I.T. Phil is limping around home with a cane (So am I!). . . . **Bill Brackett**'s death in May was particularly sad because he had made such a brave fight and come-back from his crippling operation. But he hobbled up here three times from Duxbury to see me.

Alton Cook writes that he is slowing down and is taking it easy so he can take care of his rose garden this summer. He writes, "I still have faith in 1915." Great! . . . **Wayne Bradley** continues to commute between his home and business way down in Connecticut to his Inn way up at Warun, N.H., stopping here one night each week to see me. . . . **John Dalton**, in Providence, feels we were wise not to have a big class party this year. He says we are getting too old. . . . **Frank Hull** wrote he was wintering in Florida with lots of golf — lucky! . . . **Ben Lapp** retired in Buffalo and has a great-granddaughter. . . . **Evers Burtner** phoned from his retirement in Kingston, N.H. It does me good to hear from so many classmates. . . . **George Easter** recovered from his fractured leg well enough to see his granddaughter married in May, down on Cape Cod.

On May 25, **Wally Pike**, **Wayne Bradley**, and I, representing our class, attended the dedication ceremonies of a commemorative plaque on the site of the Rogers Building, the first home of M.I.T., at the New England Mutual Life Insurance Building at the corner of Boylston and Claredon Streets in Boston. Do you remember Rogers? It was an impressive ceremony and we were glad to be there.

Vince Maconi's widow, Marion, wrote that she was going to Scandinavia with some of her family. Good for her.

Where's my cane? — **Azel Mack**, Secretary, 100 Memorial Dr., Apt. 26A, Cambridge, Mass.

16

Our 62nd Reunion was rainy on the outside but sunny on the inside. As **Walt Binger** so aptly stated: "It was the best we ever had." The picture accompanying these notes identifies those who did attend. Unfortunately, a combination of the weather and various ailments kept some of our regulars from attending.

Henry Shepard called to tell us that Frances had broken her arm, making it impossible to attend. **Hy Ullian** called to say that he and Frieda could not attend because of Frieda's brother's illness. **Dave Patten** called to say that he and Dorothy could not attend. They had just returned from a wedding, and he was still having trouble with a broken hip. The weather kept Grace and **Dan Comiskey** from coming down for the clambake. Bettina and **Doug Robertson** couldn't come because she is suffering from a leg ailment. Betty and **Charlie McCarthy** wrote that they will plan for 1979 but had to pass it up this year.

Willard Brown wrote: "How I envy you all that shore dinner and, of course, the elegant oysters which we don't get here. Neither do we get good Maine Lobster, 'tho we get by with the local huge crayfish! Please report me in good health, eating everything and very lively indeed. I lead two of my groups — the Navy League and the Men's Garden Club — in the pledge of allegiance to our flag (in my best V.M.I. manner). I certainly do always have them in well-nigh perfect cadence." **George Maverick** wrote: "I certainly wish Ruth and I could be with you at the meeting on June 7-9. We found the names of those of you that will attend particularly appealing. But it can't be. We fly to San Antonio on June 7 to attend a Maverick reunion that will bring together 200-300 of my brothers, sisters, nieces, nephews, grandchildren, etc. The Maverick tribe is a large but very close-knit gang. So, have a good time and know we miss you." Hope and **Theron Curtis** also were not present due to Hope's recent hospitalization and convalescence. However, when he wrote there was still the possibility of attending, so it may have been the rain which made it impractical to attend.

I had this nice letter from Lois (Mrs. **C.W.**) **Lawrance**: "At Christmas time the **Duffs** wrote to

say that they hoped I would continue to attend 1916 calmbakes, even without Charlie. It is good to be wanted. However, I and our friends, Margaret and Albert Alberghini, shall miss it this year as I plan to be visiting my daughter in Pennsylvania early in June. Charlie always had a very happy time at reunions and kept looking forward to 'next year.' Have a memorable reunion! With greetings to you all."

One of the items that was discussed was future reunions. The feeling is that we should continue annual reunions at Chatham. Also, we should consider supplementing these with a late fall or winter meeting along Route 128 or in the Boston area and, if possible, tie it in with an activity at M.I.T. **Francis Stern** offered to organize a mid-winter meeting in Palm Springs. It was also suggested that we write letters to those who missed our reunion because of ailing spouses to tell them we missed them. We would encourage them in the future to consider the merits of attending alone, thereby adding to the joys of old friends at the reunion and then sharing these experiences and the good wishes of classmates with spouses upon returning home. It was obvious to all present that the smaller the group the closer we become to each other. Certainly there is some sadness because many of those who once shared these reunions with us have passed on.

Francis Stern and **Paul Duff** did much to lighten our minds and our hearts with their rapid exchange of jokes on a "can-you-top-this" challenge match. Francis, in the role of the challenger, started off with a joke about a toilet seat and the champion matched it with his own toilet seat joke. Then it was on through out-houses, Jewish jokes, nun jokes, domestic jokes, St. Peter jokes, etc., and when it was all over Paul was declared the winner and still champion. Francis vowed to come back next year and take the title.

Later in the evening **Barney Gordon**, with able piano accompaniment of his grandson, Jeremy, sang such old favorites as "Some Enchanted Evening," "If I love You," "Stouthearted Men," "Indian Love Call," "Mother Macree," "Too La Roo La Roo Lal," "Rose Marie" and, of course, his specialty — "Old Man River." He also sang a number of songs from Tech Shows in which he had roles and led us in group singing ("The Stein Song," "The Wiffenpoof Song," "God Bless America," "Over There," "Smile Awile," and many more). As a historical note, Barney told us that the "Stein Song" was composed in the old Brunswick Hotel in 1880 on a day and a time when his father was present. Barney has always sung beautifully at our reunions and this year he was at his best.

In the course of our class meeting, glowing words of praise were spoken by all for the wonderful job **Jap Carr** does for us as our class agent. Gratitude was also expressed for the continuing good job that our people do on the *Review* columns. Also, **Nat Warshaw** and **Paul Duff** were elected to membership on the advisory council of our class.

In the heavier discussion, there seemed to be a feeling that the constituency is developing a strong leaning towards conservatism, that newspapers are becoming less reliable as a source of the important news and less dependable as a consistent advocate of a particular political philosophy, that more women and businessmen should go into politics, that the economic and social programs encouraged by the Roosevelt administration continue to dominate adversely the economic outlook for this country.

A final note — while Anne and **Izzy Richmond** didn't make it this year, they look forward to being with us for our 63rd. In a telephone conversation in mid-June Izzy said he is enjoying excellent health. Anne was a little distressed because a broken finger was keeping her off the golf course. . . . Keep your letters coming and keep breathing. — **Ralph A. Fletcher**, Acting Secretary, P.O. Box 71, West Chelmsford, Mass. 01863

17

Stan Dunning reports that a great many inquiries are coming in requesting information on our upcoming 61st Reunion, which will be held at the Sheraton Hotel in Sturbridge Village on October 10, 11, and 12. You shouldn't miss this event.

The following salty comment from **Johnnie DeBell**: "I still exhort Messrs. Ribicoff, Weicker, and Moffett to quit debauching the currency by appropriating huge sums of money which they do not have (as recommended by Karl Marx to ruin a capitalistic country). . . . **Harry Wansker**'s career was of such interest to his associates in Boston's Aleppo Shrine that they are publishing his autobiography in their monthly magazine. We note some of the highlights. After graduation, he joined the Navy in the "Bureau of Yards and Docks" where he became involved in developing and inventing elements of the world's first guided missile. He retained throughout his life his dedication to the service, and was active in various military associations. After Navy service, he turned to industrial inventions, including pioneering work in hydraulic shock absorbers for automobiles and patents for sheet insulation utilized in home appliances. Later he began a distinguished career in industrial relations and government contracts at the United-Carr Fastener Corp. One of Harry's most distinguished jobs was his service as President of the Boston Regional Conference on N.A.T.O. affairs. He presided over the first and only N.A.T.O. meeting held in the United States. As the only U.S. delegate to N.A.T.O. for several years, he was sent to Europe on many occasions and entertained by various Heads of State. In 1961, he completed his active N.A.T.O. association, retired from United-Carr, and shortly thereafter, moved to Sarasota. We regret, however, to end on a sad note. His wife, Isabel, supporting companion of 30 years, died on December 20, 1977.

Ken Lane says he is still active in the Coast Guard Auxiliary and spends the standard ratio of ten hours of work on the boat for every hour of use. . . . **A.P. Sullivan** has been hospitalized four times this past year for one to three weeks. He had a youthful allergy that has now returned in what is called "asthmatic bronchitis," and while not too serious, he says "It is disconcerting to find oneself unable to breath occasionally."

Joel Campbell continues to enjoy good health and maintains his yard and small garden in his retirement home at Ft. Collins, Colo. His daughter, Sara, with her husband and two children, live only 45 miles away in Estes Park, which he can reach by a scenic drive through Big Thompson Canyon. . . . **Harry Fine** writes from his retirement home in Sarasota. He was superintendent of the American Coated Paper Co. in Pawtucket, R.I., until his retirement. He has a daughter in Providence, R.I., and his son is a Vice President of the American Chain and Cable Co.

Bill Eddy writes that last fall he "swallowed the anchor and sold my sloop." All that is left now is his wife's Boston Whaler and a Stinkpot named *Phew*, which is used for fishing. Bill retired five years ago and now he and his wife spend all winter in Florida. . . . **Dick Lyons** still is in Houston and participates in some oil and gas production. He continues to serve as a Trustee of the University of St. Thomas and on the board of St. Joseph Hospital Foundation. He has given up growing roses and now his interest is in flowering plants such as azaleas, which don't require as much attention.

Frank Peacock called one day in April to say he had just seen a program on Public TV called "Affair in the Air" with a program filmed at the annual Experimental Aircraft Association's Fly-In Convention in Oshkosh. Suddenly there appeared on the screen, as large as life, **Ray Brooks**. Ray was representing the World War I Flying Aces. Alerted by Frank, we saw it later on Connecticut Public TV.

Warren Tapley and his wife, Gladys, are enjoying retirement at West Falmouth and love it even through the winter. Tap has one daughter, a Wellesley graduate, and three grandchildren. One boy is a Phi Beta Kappa at Amherst. A second boy is a graduate of Brown, and a girl is in her third year at Brown.

Ray Stevens and **Stan Dunning** recently had a specially invited tour of the Charles Stark Draper Labs. They were amazed at the things shown them and described by staff members. They also had a talk with Stark Draper himself, who recently had a Chair named for him at the Institute. There were exhibits of the devices that made possible the world orbiting satellites, and other activities for missile guidance over great distances with amazing accuracy. They saw instruments descended from computer sciences which come close to thinking for plane and submarine officers.

Sally and **John Holton** are now comfortably settled in their retirement home in "Foulkways" at Gwyneed, Penn. It is a five-room apartment just 20 miles northwest of Philadelphia, with all utilities and three meals a day. Johnnie has even moved his woodturning lathe into the hobby shop. That sounds like living.

Allyne Litchfield writes from his home in Grosse Point Park, Mich. He and his wife, Marie, continue to have good health and enjoy life. Al plays Gin Rummy weekly with a group of friends, and Cribbage with another gang on another day of the week. Al served in the Navy in World War I and then was employed by U.S. Rubber in Hartford, Detroit, and for many years, in Montevideo, Uruguay. They really enjoyed the people and living there. Al and Marie have two daughters and four grandchildren. We expect to see them at our 61st Reunion in October.

On May 30 there was a ceremony at the New England Mutual Life Insurance Building on Boylston Street in Boston. A Bronze plaque was unveiled commemorating the site of the old Rogers Building. **Ray Stevens** and **Bill Hunter** represented the Class of 1917.

We regret to report that **Noah Gokey** died on June 20. The news was transmitted through Noah's daughter-in-law to Frank Peabody. He had suffered for some time with a terminal illness.

We also regret to announce the death of **Wendell B. Ford**, brother of **Leslie Ford**, on June 3, in St. Paul, Minn.

Another sad note. **Les Christison** reports the death of his wife, Helen. Les lives in Florence, Mass., and has two sons and several grandchildren. He enjoys outdoor life and gardening. Our sympathy to Les for his loss.

A letter from Jim Ramsey in Plainfield, Ind., notifies us of the death of his mother, Betty, widow of **Ray Ramsey**, on May 19. Ray and Betty are survived by their son, Jim, a granddaughter and two grandsons. — **William B. Hunter,** Secretary, 185 Main St. Farmington, Conn. 06032

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Time marches on — with occasional interruptions that gladden the heart to overflowing. Such was our 60th Reunion at the M.I.T. campus on June 8 and 9. Those present included Dolly and **Eli Berman**, Eunice and **Ted Braaten**, **Jim Bugbee**, Hazel (Mrs. **S. W.**) **Fletcher**, Dorothy and **Edward Gore**, Frances and **Pete Harrall**, Eleanor and **John Kilduff**, Hannah Katz and **Nathaniel Krass**, Gladys and **Leonard Levine**, Dorothy (Mrs. **Edwin F.**) **Rossman**, Selma and **Max Seltzer**, Rhoda and **Charlie Tavener**, Mildred and **Charlie Watt**, and Winifred and **Sumner Wiley**. The Institute made us most comfortable at our headquarters — the Sonesta Hotel, facing the Charles River. The festivities started with a get-together and dinner followed by the Boston Pops concert at Symphony Hall; the next day, the Alumni Day (now called Technology Day) exercises took place on campus; and, all too soon, the final banquet — on the 33rd floor of the State Bank and Trust Co. building (arranged through the courtesy of Bill Edgerly, '49) where the view of Boston Harbor was magnificent. We enjoyed the nostalgic movie prepared by the M.I.T. Historical Collections showing activities at M.I.T. from its beginnings to today. But most of all what distinguished this reunion was a feeling of belonging to each other that made us swell with pride and emotion to be the M.I.T. Class of 1918. There was no question that each of us felt the 60th to be our best reunion. The only regrets were that so many of you were unable to join us and so many others have gone to their final resting place.

All of which leads to my recording the passing

of **Julie Howe**, who had been our class agent for many years. He had been very active in preparing plans for our 60th, but became ill about two months ago and passed away on June 5. A memorial service took place June 9 — Alumni Day — and with red coats most of us went to the beautiful Congregation Church in Wellesley (where he had served as treasurer for many years) to hear a most impressive eulogy. His daughter wrote a letter, read by the minister, telling in a simple but dignified way of the love that had tied their family together, of the esteem of their fellow citizens for Julie, of his dedicated service to his home, his church, his town, and M.I.T. Saying goodbye is difficult and sad, but somehow those two hours made us feel that Julie and Elizabeth were with us on this 60th Reunion — and etched in our minds and emotions that this Class of 1918 is bound together in life and in death.

We also record the deaths of **Leslie N. Iredell**, of Tampa, Fla., **Robert L. Gifford**, of Center Harbor, N.H., and **Robinson Rowe** — and I'm sorry to say I have no more details about the first two. **Robinson Rowe**, born in Spencer, Mass., entered Harvard at age 15 before he came to M.I.T. He moved to California soon after receiving his degree and was a consulting engineer there from 1921 to 1933. He was a construction engineer on the San Francisco-Oakland Bay Bridge in 1933. From 1937 to 1938, he served with the U.S. Forestry Service in Alaska and was national director of the American Society of Civil Engineers from 1955 to 1958. He died May 4 in Sacramento, Calif., where he had lived in recent years.

Pleasant news of the Harralls, starting with a certificate of merit from the Baltimore Chamber of Commerce: "To our dear friend, **Edwin R. (Pete) Harrall**, who saw the birth of this Chamber of Commerce, and lived with it, and supported it during its growing years, we present this certificate in appreciation and with affection. Involved throughout his life in right and important causes, 'Pete' has set an excellent example for those who could contribute to the betterment of the community and the nation. He served on this Chamber's Board of Directors, and on the Professional Development Council, and handled many special assignments with excellent performance. He is beloved by a host of friends — and most of all by his wife, Frances. He will long remain in the hearts of Chamber members for his contributions in starting, nourishing, and guiding this organization." We also note that Frances participated in a panel discussion — "Baltimore: Its Culture and Its Values" — run by the Humanities Institute, Inc.; she focused on "Corporate and Professional Ethics." How I and the rest of '18 would have loved to have attended that seminar!

I had the privilege of attending dedication ceremonies for the commemorative plaque at the site of the Rogers Building — now the headquarters of the New England Mutual Life Insurance Co. It was a most pleasant occasion — one especially significant to '18 because Chancellor Paul Gray placed **Sam Chamberlain**'s etching of the Rogers Building on permanent display in the general offices on the 9th floor.

Jorge Polo writes that he has taken my season's greetings card from December, 1976, and had it framed and hung up on the wall — the card shows a picture of M.I.T.'s Great Court. . . . **Bill Foster** says his health is improving: "I hope that after a few weeks or months more I will be able to do many of the things that I have had to forego this last year and a half." He sends warm regards to everybody. . . . A note from **Ed Mead** states that he is still in Carolton Convalescent Chronic Hospital in Fairfield, Conn. Is there anyone in the Connecticut area who can visit him and report to me? I'd appreciate it. — **Max Seltzer**, Secretary, 60 Longwood Ave., Brookline, Mass. 02146; **Leonard Levine**, Assistant Secretary, 519 Washington St., Brookline, Mass. 02146

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Dr. **Eugene Smoley** (Gene to us all) did such a superb job as class secretary that I start to take over, feeling quite inadequate. However, with your help I shall do my best. Send me a few or more words about yourself. The 60th Reunion committee is being activated and you will be hearing about the reunion through this column.

We are advised that **George C. McCarten** died on October 15, 1974 — a courageous and fine classmate. Also, we are advised of the decease on December 6, 1977, of **Clarence W. Bates**. **Don Way** sends me a clipping reporting the decease of **Earl P. Stevenson**, former head of Arthur Little, Inc. who got his master's degree at M.I.T. in 1919. Don Way also informs us that from alumni funds of Class of 1919, $2,000 was used to provide a chair in the recently modernized Room 10-250 in the name of the Class of 1919. — Your new Secreary, **W. O. Langille**, Box 144, Gladstone, N.J. 07934

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It is exceedingly pleasant to report an extra fine turnout of the Class for Alumni Day. Present at one time or another were **Norrie Abbott**, **Ed Ryer**, **Al Burke**, **Ed Wason** and daughter, Barbara, Cay and **Frank Maconi**, **Phil Wait**, Marion and **Warren Chaffin**, Mina and **Perk Bugbee**, and, of course, your secretary and his Amy. This augers well for our 60th which will be coming up in the not-too-distant future.

A welcome note from **Moe Lipp** says that he and Helen are looking forward to the 60th. Moe says he still roots for the Red Sox and the Bruins but now favors the Miami Dolphins. The Department of Justice recently cited Moe for his energetic and unselfish efforts on behalf of the United States at a patent hearing. The success of the case was due in part to Moe's "enthusiastic good citizenship in serving the people of the U.S." Good for you, Moe. We look forward to seeing you in June, 1980.

It is my sad duty to report that the Class has sustained heavy losses in the passing of several prominent and beloved classmates.

Scott Carpenter of 80 Simonds Road, Lexington, Mass., died on March 17. He was one of the first commissioned Navy pilots of World War I and was a retired engineer at M.I.T.'s Lincoln Laboratory. Active in Masonry, he was a member of St. Bernard's Masonic Lodge in Southboro and a life member of the Royal Arch Chapter of Massachusetts. He was an active member of the National Association of Watch and Clock Collectors. He is survived by two sons. . . . Word has just been received of the death of **Harold F. Hunter** of Toine, Georgia. He had long been associated with Celanese Corp. of America in Rome. The date of his death was November 28, 1977. . . . **Mrs. Arthur Dreyer** of 408 E. Drury, Kissimmee, Fla., died on September 8 last year. No details.

Larry Burnham of 55 Summer St., Kingston, Mass., died on June 22. He started as engineer for Firestone Tire and Rubber Co. and Hood Rubber Co. On moving to Kingston in 1939 he became manager of E.S. Wright Co. Later he acquired ownership of the business. Larry was former member and chairman of the Kingston School Committee. He was on the corporation of the Plymouth Five Cents Savings Bank. He leaves his widow, Olive, a daughter, son and six grandchildren. A friendly and always cheerful character, he was a deservedly popular member of our class. — **Harold Bugbee**, Secretary, 21 Everell Rd., Winchester, Mass. 01890

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In the May issue I reported that the 50th wedding anniversary of Millie and **Herb Kaufmann** was celebrated this June. **Larcom Randall** sends a clipping from the June 15 issue of the *Siesta Key Pelican* showing pictures of this couple now and 50 years ago, and I can record that the 50 years have treated them well. Herb is director emeritus of Rosario Resources, Inc. and has long been active in the Siesta Key Association, and Millie ran an early american antique shop in Pound Ridge, N.Y., before moving to Sarasota. **Larc Randall** reports the Gulf water temperature at 84 degrees. It was not that this past February — brrr!

Reports come from **Bob Miller** and **Irving Jakobson** that Alumni Day attendance this year was down to four '21-ers: Jake, Bob and Helen, and **Don Morse**. After luncheon Don and Jake visited the crew house and saw the two new four-oar shells contributed by H. W. McCurdy, '22. Jake was moved to find one of the shells named "Jake Jakobson, Class of '21." Bob reports stopping to see Emma and **Al Lloyd** on the way up to Cape Cod in May and finding Al looking well and active, much recovered from his heart attack last year. Bob also saw **Don McGuire** and **Whitney Wetherell** at the Orleans Coffee Club meeting in early June.

George Schnitzler of Plantation, Fla., responds to my appeal for news with a good letter: "I retired in the early 1960s after spending 38 years with the National Bureau of Standards in Washington, D.C. Since then my wife and I have divided our time between Brookline, Mass., and Florida. Florida is now our permanent home in a place near Fort Lauderdale. Until recently I played lots of tennis but a bad back has forced me to lead a sedentary life. I attended a recent M.I.T. Club meeting at Carl Schwenzfeier's ('41) beautiful home in Ft. Lauderdale at which **William L. Knoepke** was present. We were the oldest alumni there — a very pleasant gathering with entertainment by the M.I.T. Logarhythms. Later this summer, Anne and I hope to take a trip to the Scandinavian countries."

A letter from **Helier Rodriguez** tells of his celebrating his 80th birthday March 25 after he and Graciola returned from the Fiesta in Mexico. A job on his list was packing and mailing to **Jay Stratton** a camera left behind in Mexico. The Rodriguezes had lunch three times with the **Vivano Valdeses**, once with Helen and **Bob Miller**, once at Conchita Lobdell Pearson's and once at the Valdes home. After the Fiesta they stayed at Conchita's for ten additional days. Helier reports seeing Claudia and **Josh Crosby** at the annual M.I.T. Club picnic. The schedule for this year's Fiesta sounded exhausting to your Secretary. Incidentally, 1921 was the oldest class attending.

Your Secretary attended the Simmons Class of 1923 55th reunion with his spouse, staying at the Simmons dormitories several nights. Hazel and **Whitney Wetherell** came up for Alumnae day and Whit and I sat out under the trees on campus and reminisced. During his business career Whit worked for Stone and Webster, but most of his years were with Carrier Corp. as chief engineer for the N.Y. district. His biggest engineering job involved the successful bid for the air-conditioning in the United Nations Building. He also engineered cooling systems for several breweries, but failed to state whether his "perks" included free beer. Another '21er encountered at the Simmons reunion doings was **Mark Hamburger**, with whom I chatted several times. Incidentally, the Simmons '23 class secretary is Katrina Bittinger (Mrs. **G. Frank**) **Lord**.

Two Alumni Fund envelopes bring in a little news: **Eugene S. Clark** of San Diego, Calif., writes that he attended his 60th at Dartmouth this June and hoped to make our 60th in 1981. . . . **Leo C. Pelkus** writes, "Vivian and I have just returned from our annual winter vacation at Key Biscayne, Fla. We have two grandsons, age 7 and 4 — oldest is Leo."

It is my say duty to report the deaths of seven more classmates: **John N. Worcester**, Dover, Mass., December 17, 1976; **Eugene L. Harlin**, West Plains, Mass., September 20, 1977; **Egbert W. Olcott**, Long Valley, N.J., November 10, 1977; **Hartwell Flemming**, Arlington, Mass., December 20, 1977; Brig. Gen. **James E. Baylis**, Hathesburg, Miss., March 22, 1978; **Dayton T. Brown**, Manhasset, N.Y., June 20, 1978; and **Edouard N. Dube**, Reading, Mass., June 30, 1978. A letter from General Baylis's nephew advises of his death at the age of 94. He was buried with full military honors at Fort Sam Houston National Cemetary. . . . Ruth and **Irving Jakobson** attended a memorial service for **Dayton Brown** on June 26. Dayton rowed with Jake on the crew at M.I.T. and they were good friends ever since. Living near each

other, the Jakobsons got together with the Browns frequently. The Browns contributed to the support of the North Shore University Hospital and one entire floor is named in their honor. Dayton established the Dayton Brown Company in Bohemia, Long Island — a testing laboratory for all kinds of manufactured devices and also a maker of sheet metal for cabinets. . . . Ed Dube was one of the class stalwarts, serving on reunion committees, nominating committees and as long-time Class Agent. During his career, he worked for the National Park Service, General Electric Co., Treasurer of Stewart Associates, and consulting engineer (structural design). We shall miss him — and the sympathy of the class is extended to the families of all these classmates.

My West Coast correspondent **Grant Miner** tells of his writing efforts: "When Helga and Stewy (**James Stewart**) **Parsons** were out here a year or so ago, she read my opus about my first day at school and had some comments for its betterment. I rewrote it, sent it to her along with some other chapters and asked for a non-candied criticism. She let me have it with both barrels — just what I wanted. I wrote back to express appreciation for all that time and energy for me. She wrote a treatise of nine long-hand pages which was really a short course in writing — then she edited both stories and my letter to her. [Helga is a script writer from way back in the days of radio serials.] Her timing was perfect. Her opus came on my 80th birthday — nice present." — **Sumner Hayward**, Secretary, 224 Richards Rd., Ridgewood, N.J. 07450; **Josiah D. Crosby**, Assistant Secretary, 3310 Sheffield Cir., Sarasota, Fla., 33580; **Samuel E. Lunden**, Assistant Secretary, Lunden and Johnson, 453 South Spring St., Los Angeles, Calif. 90013

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We hope that many of you had happy times at Technology Day in June. Your Secretary had the tickets for all events and had to cancel flights the last day. Our file contains a snapshot of the Spalding Inn Club News, showing beautiful views of the White Mountains and groups of bowlers hosted by our own **R. E. "Bunt" Spalding**. They were outstanding in their hospitality to our Class last year. We note that there are 391 active Alumni listed in our Class Agent's report, and we had 34 per cent participation.

We also note in our files a challenging picture sent by Catharine and **Mac McCurdy** of *Blue Peter*, their livable and adequate pleasure craft sailing near Seattle. Also a note from Carlys and **Frank Kurtz**.

We have a card dated May 10, 1978, from Madeline and **Parke Appel**, sent while visiting their daughter, Joan, in Madrid. They had celebrated their 54th wedding anniversary. The Appels visited **Yardley Chittick** on Captiva Island in February and saw **Ray Ellis** at the Venice Club picnic in April on Casey Key. Parke noted that **Bunt Spalding** was in Sarasota in February and March. He is still official photographer of the Sarasota M.I.T. Club and roving Ambassador. Incidently, Parke sings in the church choir and is on the Board of Directors as Vice President of the Condominium Corp. He tells of visiting the Ray Ellis, **Buck Eacker**, and **Don Carpenter** families last summer. We have a great President.

We are indebted to **Bill Elmer** for continuing to send us *ERGO*, full of challenges to M.I.T., Harvard, and B.U.

William H. Mueser has been invited to be a member of the National Academy of Engineering, the highest professional distinction that can be conferred on an engineer. They acknowledge his work in advancing the design technology of deep foundations as applied to major building, bridges and drydocks.

Wyatt H. Ingram of New York notes that he has retired, but continues to "putter around on the electrical network theory." . . . **Phillip B. Holmes** of Dunedin, Fla., is continuing to enjoy his two daughters, seven grandchildren and two great-grandchildren.

We send the sympathy of our Class to the family of **Frederick J. Guerin** of Lawrence who was a teacher in various universities until he retired in 1968. . . . Also we note with sorrow the passing of **John C. Molinar**, former Vice President and General Manager of the Niles-Bement-Pond Co. Jack had also served as Executive Vice President of both the Pratt and Whitney Co. and the Union Twist Co. while living in Darien, Conn. He served as Police Commissioner, was President of the Republican Club and was a member of the American Security Council. Our sympathy goes to his wife, Gladys and their three daughters.

Many good wishes for a pleasant summer while looking toward another possibility of a Class Reunion soon. — **Whitworth Ferguson**, Secretary, 333 Ellicott St., Buffalo, N.Y. 14203; **Oscar Horovitz**, Assistant Secretary, 3001 South Course Dr., Pompano Beach, Fla. 33060

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Our 55th Reunion began on campus in Cambridge with registration at the Hyatt Regency Hotel on Memorial Drive. We were guests of the Alumni Association due to overbooking of McCormick Hall. Starting at 4:30 PM busses took our crowd to that building for cocktails and dinner. Later that evening we boarded busses for Symphony Hall where we enjoyed the music of Arthur Fiedler's Boston Pops. Arthur was wearing his cardinal red M.I.T. jacket and at the conclusion of the concert we all stood and sang "Arise Ye Sons of M.I.T."

On Friday we attended the morning program at the Kresge, followed by the memorial service for departed classmates at the M.I.T. Chapel. Following lunch and the afternoon program, most of us sallied forth to West Dennis to the Lighthouse Inn on the south shore. Another cocktail party was followed by dinner and the distribution of thank-you gifts for past service to **Horatio Bond**, **Herbert Hayden**, and retiring Secretary/Treasurer, **Tom Rounds**. The first installment of **Al Allen**'s movies of past reunions, starting with the class picnic of 1923 and humorously narrated by Mary Sterling, concluded the evening's activities. Attending various portions of the reunion were:

At M.I.T. Campus: Mr. and Mrs. **Laurence E. Barstow**, Mr. and Mrs. **Sherwood I. Berger**, Mr. and Mrs. **Fernando de la Macorra** and daughter, **John A. Frank**, Mr. and Mrs. **Harry Green**, Mr. and Mrs. **Ray Holden**, Mr. and Mrs. **Olcott L. Hooper**, **W.B. Greenough**, Mr. and Mrs. **Masick C. Magarian**, **Albert J. Pyle**, Mr. and Mrs. **James M. Robbins**, and **Dorothy W. Weeks**.

At M.I.T. and the Lighthouse Inn (except as noted): **Alan R. Allen**, **Frederick O.A. Almquist**, **Edward S. Averell**, Mr. and Mrs. **Horatio L. Bond** (Cape only), Mr. and Mrs. **Herman A. Bruson**, Mr. and Mrs. **Louis Domingues** and granddaughter Chris, Mr. and Mrs. **Thomas B. Drew**, **Roger Cutting** (Cape only), Mr. and Mrs. **Clarence V. Chamberlin**, Mrs. Arthur (Phyllis) Davenport, Mr. and Mrs. **Gerald A. Fitzgerald**, Mr. and Mrs. **Richard H. Frazier**, Mr. and Mrs. **Rodney M. Goetchius**, Mr. and Mrs. **Earle A. Griswold**, Mr. and Mrs. **Elliot P. Knight**, Mr. and Mrs. **John W. Beretta**, Mr. and Mrs. **Herbert L. Hayden**, Mr. and Mrs. **Forrest F. Lange**, Mr. and Mrs. **William S. LaLonde**, Mr. and Mrs. **Howard A. Lockhart**, Mr. and Mrs. **Charles M. Mapes**, Mr. and Mrs. **Bertrand A. McKittrick**, **Ragnar D. Naess**, Mrs. Harold C. (Conchita Lobdell) Pearson, Mr. and Mrs. **Miles Pennypacker**, Mr. and Mrs. **James A. Pennypacker**, Mr. and Mrs. **Leander H. Poor**, Mrs. Bernard E. (Pat) Proctor, Mr. and Mrs. **Isadore Robinson**, Mr. and Mrs. **Thomas E. Rounds**, Mr. and Mrs. **George A. Rowen**, Mr. and Mrs. **Royal Sterling**, Mrs. David W. (Isabelle) Skinner, Mr. and Mrs. **Julius A. Stratton**, Mr. and Mrs. **Lyman L. Tremaine**, Mr. and Mrs. **Walter N. Webster**, **David B. Joy**, and Mr. and Mrs. **William Wolfe**.

Saturday morning saw **Pete Pennypacker**'s Kite Flying Contest under way under extremely gusty wind conditions. After many mishaps, eight kites were flying. Winners of prizes were: for kite out of sight, **Louis Domingues**' granddaughter Chris; first kite up, Elizabeth Lockhart; first kite down, Pearl Robinson; furthest kite out and down, **Tom Rounds** (but no prize since he appropriated illegally the reserve spool of ½ mile of nylon string). Golfing was another sport indulged in by many. Low gross winners were tied between **Shorty Chamberlin** and **George Rowen** — with Shorty winning the toss. The "Calcutta Sweeps" was won by **R.D. Naess**. Finally for the second highest gross score, **Miles Pennypacker**, won the oversize club and ball. Bridge indulged in by the ladies was strictly informal with no prizes. Saturday evening began with drinks and class banquet of broiled lobster, followed by our business meeting.

After short reports by Secretary/Treasurer **Tom Rounds** and President **Mapes**, the report of the nominating committee was presented by Chairman **Ray Bond**. Proposed for new class officers were: for President, **Rodney M. Goetchius**; for first Vice President, **Royal Sterling**; for second Vice President, **Bertrand A. McKittrick**; for third Vice President, **Thomas E. Rounds**; and for Secretary/Treasurer, **Richard H. Frazier**. A vote was quickly taken and the slate was unanimously voted into office.

After adjourning the class meeting, **Lem Tremaine** took over for the fun and games. The first gag was the gift of an endowment life insurance policy to M.I.T. Class of 1923 as beneficiary totaling $ 1 million upon the reaching of age 150 by one **Alan** Methuselah **Allen**. The second was the awarding of a D.C.M. (Doctor of Class Music) to **James A. Pennypacker**, who had composed music and lyrics for two songs extolling M.I.T. This, with the enrobing of Pete with gown, doctorate hood and cap (with bells) took place later in the evening. A few additional gifts were presented to **Royal Sterling**, **Lem Tremaine** and an engraved plaque to past President **Mapes** followed a large number of door prizes of varying degrees of value and hilarity. The most impressive door prize in the form of a chrome plated large fire bell (donated by **Bert McKittrick**) was taken by **Pennypacker** who immediately established a new tradition by loaning it to **R. Sterling** as past reunion chairman to be held by him for five years, at which time it would pass to the 60th Reunion Chairman for his use for the next five years and so on. At this point **Chamberlin** proposed that names of all reunion chairmen be engraved on the bell. This was unanimously approved.

Most agreed that this was about the best reunion so far experienced with much credit due to chairman **Sterling** and his committee consisting of **Pete Pennypacker** in charge of entertainment, **Rod Goetchius** in charge of golf and **Lem Tremaine** in charge of awards, gifts and gags. Sunday evening saw the showing of class reunion pictures of the 45th and 50th get-togethers in 1968 and 1973 respectively. Those remaining sang Pennypacker's "To M.I.T.," composed by him and sung for the first time at our 50th. The class is greatly indebted to **Alan Allen** for hard work and persistence in taking, editing and preserving these valuable likenesses of our many distinguised classmates.

And now for other news of classmates. From Phyllis Davenport, "Thank you kindly for your gift to the Alumni Fund in memory of my beloved husband, Dave. Dave's creed in life was to try to leave the world a little better than when he came into it. This I believe he did in his home, his school, his profession and his community. With all good wishes to the Class of '23 which he cherished." We were all glad to see Phyllis who came to the reunion with Isabelle Skinner.

From **J.A. Elfenbein**: "I am the only Harvard man and the only M.I.T. man who has a sophisticated electronic computer which indicated to the pilot the gross weight, and the c.g. position of a loaded aircraft before take-off. At age 80 I am still at it, working on new types of sensors for landing gear applications." . . . From **Joel Lund**: "Sorry I couldn't attend the reunion this year. Had to attend the graduation of my granddaughter. I fully expect to be at the 60th."

We see via the Alumni Fund that **Edward McSweeney** has just published his book *Managing the Managers* (Harper and Rowe). . . . From a letter to me from **Peter Petersen** of Bergen, Norway, we learn that he hoped for some time to attend our reunion but it proved to be impossible.

He wished us all "a rewarding get-together." . . . Via Department of the Army channels we learn that Brig. Gen. **Willis R. Slaughter**, U.S.A. retired, was on May 12 inducted into the Ordnance Hall of Fame. The Army letter goes on to say that "The Hall of Fame gives perpetual commemorative recognition to those who have significantly advanced the cause and mission of the Ordnance or Chemical Corps by their contributions."

Lowell L. Holmes of Sarasota, Fla., died April 21, 1978. A native of Minnesota, he attended the University of Minnesota for three years before entering the Institute in 1931. He received his degree of B.S. in Business Administration with us. He had a varied career in sales, sales management, teaching, college administration and business consultation. He was coordinator of training, airplane division, Curtiss-Wright Corp. in W.W. II. In W.W. I he was a member of the First Marine Aviation Corps. After the last war he founded and was president of Management Research Consultants in Indianapolis until he retired in 1959. He was a founder of the M.I.T. Club of Southwest Florida and its first president.

George F. Nevers died November 9, 1977, in Manchester, Conn. George was born in 1902 and was a graduate of the Hartford High School. He received his degree of B.S. in Mechanical Engineering. Before retiring in 1969 he was an industrial hygiene engineer with the Connecticut Department of Health in Hartford. From his widow Beatrice we hear that he fully intended to make the 55th reunion with us but the last of a series of heart attacks prevented his realization of attendance at this event. She sends her best wishes to all from her home at 755 Ellington Road, S. Windsor, Conn. 06704.

William F. Perkins of Newburyport, Mass., died July 7, 1975. He attended courses in Mechanical Engineering at M.I.T. His career was spent in industrial management, quality control and production engineering, first with Merriman Brothers of Jamaica Plain, Mass., and later with the Bliss-Cornell Co.

So long! This is the last you will hear from me, now that I have finished my ten-year stint as class of 1923 Secretary/Treasurer. The next voice you will hear in this column will by that of **Richard H. (Dick) Frazier — Thomas E. Rounds**, (retiring) Secretary/Treasurer, 990A Heritage Village, Southbury, Conn. 06488

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Barbs and **Frank Shaw**, our energetic, affable and farsighted Class President, will celebrate their 50th wedding anniversary on August 5. Frank guided marketing for Rust Craft Greeting Card Co. for many years, but does not show much corrosion, and very little has brushed off on Barbs. . . . **Homer S. Davis** in Oceanside, Calif., wrote **Dick Lassiter**, amazed that Dick remembered his much earlier association with Hearst newspapers. Eventually, Homer switched to a then small toy manufacturer, that grew to be Mattel, Inc., now a producer of dolls, bicycles, games, pre-teen clothing, children's luggage, pool tables, and the owner of Ringling Brothers-Barnum and Bailey Side Shows. Homer retired in 1970.

Eugene L. Chappell passed away January 5, 1978. He earned a B.A. degree before his S.M. in chemistry at the Institute. Our records seem to indicate that he established the Chemline Corp. in Cheswick, Penn., and was President for his enitre life.

Gilbert H. Cowan died October 11, 1977 in Sault Ste. Marie, Minn. Gib was awarded his S.B. in business and engineering administration, after being involved for four years in many activities, including *VOO DOO*, Tech Show and the Aeronautical Engineering Society. His business career has been devoted to one field. Assuring himself of clothing and house furnishings, he was for many years president of Cowan's Department Store in Sault Ste. Marie.

Colonel **Frank Fenton Reed**, U.S.A., Retired passed away March 25, 1978 in Altadena Calif. He is listed as a Class member in mechanical engineering without a degree. He graduated from West Point in 1917, served in both World Wars and after retirement was a consultant for Northrup Aircraft, Thiokol Chemical, and the M.I.T. Lincoln Laboratory. He was active in church work, a Shriner and member of the M.I.T. Club of Los Angeles.

Mark L Sinnicks (Stringer) writes, "Moved to Oakmont in the Valley of the Moon on December 1, 1977." A perfect example of the frustration facing your Secretary. A Massachusetts guy gets a chemical engineering degree and some years later writes he is a "combination time-book and storekeeper, camp boss, truck driver, miner and boiler fireman." Then in California becomes a Base Development engineer at the Alameida U.S. Naval Air Station and finally retires near Santa Rosa.

Your Secretary's lot is not a happy one. The Alumni Association has come up with a number of death notices. **Stewart B. Luce** departed March 26, 1978 in Glenwood Springs Calif. He joined us in his sophomore year and gained an S.B. and S.M. in Chemistry. It appears that he spent his career with Swift & Company, retiring to Colorado Springs to enjoy his hobbies of stamp collecting and gardening.

Roscoe E. Swift died March 8, 1978, in Augusta, Ga. Swiftie was awarded an S.B. in mechanical engineering and for a year was an assistant in the Industrial Physics Lab, joining Babcock & Wilcox in New York for at least 25 years to 1949, and later retiring to Georgia.

Percy H. Wilson passed away August 2, 1977 in Carmel, Calif. Duke came to us from the University of California for three years and received his S.B. in mechanical engineering. He was a member of Tau Beta Pi, Speakers Club, and the Mechanical Engineering Society. His career was as a civil and mechanical engineer in construction and oil refining. As his office was in the Union Oil Building in Los Angeles, we assume that he was connected with the Union Oil Company until retirement.

A note to the Alumni Fund from **Douglas Montgomery** says, "Things go along much the same. Busy and in good health." Monty had a few years on most of us and wound up in Oxnard, Calif., dabbling in electronics.

Another Fund note from **Melvin A. Perkins**, Wilmington, Del., says that he retired from DuPont in 1967, after 41 years supervising research on dyes, pigments and other organic pigments. He co-authored a book on the same subject and is listed in "American Men in Science." He expresses his deep conviction as a Christian and the vitality of eternal faith. — **Russell W. Ambach**, Secretary, 216 St. Paul St., Brookline Mass. 02146; **Herbert R. Stewart**, co-Secretary, 8 Pilgrim Rd., Waban Mass. 02168

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A recent letter from **Cyrus (Cy) Fernald** was most welcome and appreciated. It was his first writing to the class secretary since 1925. For many years Cy wintered in Florida and summered in Maine. He sold out in Maine in 1972 and is at home year-round in Longwood, Fla., and would be pleased to have classmates call on him. Long trips are much out of the question now because of some leg problems. Cy's avocation has been astronomy and as a member of the American Association of Variable Star Observers has made over 134,000 observations of variable stars in the years 1937 through 1974. That is more such observations than any other observer in the northern hemisphere has made since 1911. Of course Cy is a member of the Central Florida Astronomical Club and at its meetings usually meets up with Charlie Finnigan, '34. The Fernald family has a long history in the State of Maine — the recounting of which will have to wait for a later time.

It was most pleasant to receive a letter from **Jesse Maury**, one of the few mining engineers in our class. He had many years of experience in the mining industry which led him to consult for a number of years; then he became president and treasurer of Atlantic Perlite Co., manufacturers of building materials. He retired from the company in 1970 and went back to college, studied accounting at American University and qualified as a C.P.A. in Maryland. He now runs a small C.P.A. practice out of his home, with no personnel problems since he is his own secretary, typist and office manager. In his spare time he works at politics and is doing a good job in civic activities, mostly on the county level (Montgomery County, Md.), where they face the urban growth problems which plague the whole country. Jesse has been active in county affairs for the last 25 years. He lives in Chevy Chase, Md.

A letter from **Sam Spiker** who now calls Dublin, N.H., home, provides the following interesting note of one of his activities: "Up here I have been spending quite a bit of time raising much needed money for the Sharon Arts Center. It is an excellent area organization which operates a very good art school, gives fine exhibitions in the gallery and runs an attractive shop selling New Hampshire Arts and Crafts. It is a point of interest for any in the Mt. Monadnock area to visit. We are very fortunate to have as the president Dr. James R. Killian, Jr., '26, who lives nearby in Sharon when he is not in Cambridge." Sam enclosed a copy of a clipping from the *New York Times* noting that **Jim Clifford** had died of a heart attack on April 7, 1978 at his home at 25 Claremont Ave. in New York. Jim was Columbia University professor emeritus and was a world renowned authority on Samuel Johnson and other intellectual figures of the 18th century. "He was a man of enormous physical and intellectual energy, one of the most important reasons for revived popular interest in the 18th century," said a colleague at Columbia, English Professor John Middendorf.

"Professor Clifford traveled frequently and wherever he touched down on the globe, a Johnson society sprang up, in Japan or Hong Kong, it didn't matter where," he said. A few days before his death Jim had written a note accompanying his annual gift to the Alumni Fund saying that in 1979, McGraw-Hill will be publishing a sequel to his biography, *Young Sam Johnson*, which they published in 1955. This will be a study of Samuel Johnson's middle years with the title *Dictionary Johnson*. Jim graduated from Wabash College with an A. B. in 1923 before coming to M.I.T. During the summer of 1929 he enrolled at Columbia University where he whetted his appetite for graduate studies in English. In 1935 he was awarded a Cutting Traveling Fellowship from Columbia. From 1937 to 1944, while earning his Ph.D. at Columbia, he taught at Lehigh College. He joined the Columbia University faculty in 1946 after serving one year on the facutly at Barnard. He continued at Columbia until his official retirement in 1969. Jim is survived by his wife, Virginia, two sons and a daughter.

Milt Salzman has sent me an enthusiastic report of his attendance at the M.I.T. Fiesta in Mexico. He reports as follows: "We met in Mexico City on March 8 and the next morning traveled by bus through picturesque rural Mexican country northwest to Guanajuato which is a small 16th century town preserved almost intact by the Mexican government. Here we were housed in a real Spanish haciendo-type hotel and entertained royally for three days and nights with tours of the underground streets, markets, silver mines. We visited the University and an old-time Cervantes pageant and a strolling 'Callejoneada' accompanied by Spanish costumed musicians and a wine-bearing burro to replenish our 'porrons.' There were also talks by the honored guests, outdoor barbecues and a final dinner dance." Also in attendance from 1925 were **Gil Tarleton** and his wife Gladys from Green Valley, Ariz. Milt encourages other members of the class to try to attend future Fiestas. He intends to make it three more times to earn the "Eager Beaver" award.

Gil Noble writes from his retirement home in Winter Park, Fla., to say he is enjoying stamp collecting and publishing stamp catalogs and albums. Also, he raises and races harness horses.

Perhaps you noticed no 1925 notes appeared in the March/April issue of the *Review*. The reason — space limitations necessitated postponing some of the material submitted until the May issue. The editor informed me that by a flip of a coin two classes had their reports postponed and

1925 won.

Our class was well represented at Technology Day in June. We filled one table to overflowing at the luncheon. Attendees were: President **Chink Drew**, **Will Gardiner**, **Jim Howard**, **Ed McLaughlin**, **Frank Mulcahy**, **Milt Salzman**, Elinor and **Sam Spiker** and your secretary.

It is with sorrow that I must record a number of deaths reported to me during the past several months. A note was received from Ann Tumser telling of the passing of her father, **Coolidge Hastings** on May 28, 1978. He had lived in Orange, Calif., for the past five years and for some time had suffered from arteriosclerosis. He had gone to a nursing home just prior to his death.

Mrs. Fisher H. Pearson of Weston, Mass., has sent me a clipping from the Wayland-Weston *Town Crier* reporting her husband's death on May 22, 1978. **Fisher Pearson** was born in Lowell, Mass., attended Lowell High School and entered M.I.T. with our class. After seven years with the Boston Packard Co., he became a publisher's representative and his accounts included *Life* magazine in its early days. In 1944 he joined the Cleveland office of *U.S. News and World Report*. In 1955 he became regional sales manager of its Boston office and moved to Weston. He retired in 1969. He is survived by his wife, Nancy, a daughter and three sons.

Three others who attended M.I.T. with the class of 1925 have passed away: **Charles Jewett** in Vero Beach, Fla, on November 14, 1977; **William Ketchum** in Birmingham, Ala., on April 15, 1977; and **George Stetson, Jr.** in Montega Bay, Jamaica, on December 9, 1974. No details are available concerning these classmates. — **F. Leroy (Doc) Foster**, Secretary, 35 Woodland Way, P.O. Box 331, North Chatham, Mass. 02650

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Tuesday, July 4, 1978 — Unbelievably it is 15.5 degrees Celsius with an accompanying cold rain here at Pigeon Cove. The holiday sailboat races will be a washout — and the holiday chowder too. This is rather disappointing to some, but we have had many delightful days. The small wall (16 feet high) has been rebuilt with huge boulders and a 30-ton crane, and the footings are in for the 52-foot wall which will be of reinforced concrete. The town is showing remarkable resiliency in its comeback. Come and take a look!

Alumni Day produced a good '26 turnout for an off-reunion year. I failed to make a list of attendees because the names usually arrive in the mail, but my negligence became evident when the list did not show. So why don't I say, "All the regulars were there!" **Benny Margolin** and Ruth reported that **Chet Buckley** was in town but at the Mass. General Hospital. Chet was stricken at a directors' meeting in Boston which, if one must be stricken, seems to be a proper place. At any rate I phoned Chet a few days later and he was packing for his return to Sarasota. Benny reports good progress for Chet and some satisfaction that a five-week European trip had not started.

Benny also reminded me that **Angelo Maschi**'s death on January 9, 1978, had not been covered. Angie had made a real name for himself in the New England electronics industry — I talked with him occasionally but Ben saw him frequently. For the class we extend sympathy to Mrs. Rose Maschi. . . . **Elton Staples**'s wife and I were comparing sciatic nerve problems at the Alumni Luncheon. She uses traction — I use aspirin, and luckily the best possible therapy seems to be getting into the sailboat and racing vigorously for about four hours. It sounds crazy — the seats are uncomfortable, the positions ungainly and pulling on the main sheets should be fatal — but it works. How can I do it more than two months each year?

Our classmate Cantor **Morris Minsk** missed Alumni Day. During the "great blizzard of '78," he had difficulty returning to Washington because his car was snowbound for a month and then required a lot of service. Upon returning to Washington, Morris visited **Thornton Owen** in his "new, very nice and spacious quarter on the second floor of the Perpetual Savings and Loan

Standardization

It requires long, hard work... fortitude... endurance... patience, lots of it... devotion... abiding faith that the work will be completed some day—never give up... It requires knowledge and understanding in depth: from the basics to a full grasp of all that is of consequence and determining (engineering, economics, the full gamut of experience past and present)... of course, it requires intelligence and judgement of a high order: they are the guiding light and play a dominant role. And to these I know only too well you and others can add more that are equally significant.

The striking question frequently raised: Is it worth it? Yes, it is, for this truly is part of the good life of the engineer... the embodiment of his profession: to render an enduring service in the world we live in. This in itself is one of his great rewards.

P. L. Bellaschi
June 15, 1977

For 50 years — ever since receiving his master's degree from M.I.T. in 1928 — Peter L. Bellaschi, '26, has worked in power engineering — electric power transmission, high-voltage engineering, insulation, and power transformers. In those 50 years (first for Westinghouse Electric Corp. and since 1947 as a private consultant for industries and utilities throughout the world) he's achieved a healthy respect for standardization, the worldwide effort to assure that components and systems meet specified goals of performance and compatibility. Mr. Bellaschi has himself participated in the work of the American National Standards Institute, and he's represented the U.S. at the International Electrical Commission and before the International Conference on Large High-Voltage Electrical Systems (Paris). The statement reproduced above, written in 1977, expresses his commitment to this one important aspect of professional engineering.

Association of which he is chairman." . . . **Bob Dawes** brought his daughter Sarah to Alumni Day and made his usual vow to visit Pigeon Cove soon. . . . We saw **"Pink" Salmon** just for a handshake, and of course Liz and **Jim Killian** were at one of the '26 tables. We overflowed and I ended up at the '18 table.

Don Severance's ('38) secretary, Katherine French, recently brought us up to date on **Bob Dean** who was paid tribute by the Wellesley Town Meeting upon his retirement as Commissioner of the Wellesley Housing Authority after 20 years. He had overseen five housing developments for the town, and the new units will be named in his honor. This is the first retirement we have heard of for Bob — he still heads the architectural firm that now bears his name in first position and which in his early years with the firm restored Williamsburg.

We do have additional notes, but the mail is collected at noon so please bear with us if we hold some nice stories in abeyance. Cheerio until Fall. — **George Warren Smith**, Secretary, P.O. Box 506, Pigeon Cove, Mass. 01966

27

I have a nice long letter from **Amund Enger**, who tells me that he is thinking of paying a visit to the United States soon, for the first time in ten years. Amund retired in 1962 as a result of illness — the effect of a bout with viral hepatitis 30 years earlier — but says his liver no longer bothers him. When they left Norway in 1962, he and his wife moved to Switzerland, and in 1971 he also bought a house in the Algarve, in Portugal, where they spend the winters. He gave up skiing in 1971, but he keeps busy with golf, gardening, and shooting — trap and skeet, and also target shooting, prone, with a Swiss Army rifle at 300 meters. They get back to Norway each fall to see their two daughters and their families — five grandchildren — and there Amund does some game shooting. They watched the Portuguese Revolution and its aftermath from up close and foresee a very difficult time for the country some distance ahead.

The 1978 award of the Scientific Apparatus Makers Association went to **Nat Cohn**, who was cited for leadership, vision, and the "highest achievement in developing the industry's capacity for serving the nation." . . . **George Cunningham**, who sang with the M.I.T. Glee Club in 1926 and 1927, is still singing; he is a member of the bass section of the Saddleback Concert Chorale, a chorus of almost 100 voices, in Laguna Beach, Calif. . . . **Herb Johnson** is continuing full-time work, consulting in the fields of solid phase, metal and plastic, forming and recycling, which he notes are becoming more important as energy and materials become scarcer and more expensive. His hobby is inventing apparatus and processes; in March, he received his latest patent allowance, covering 18 claims.

Sam Auchincloss does a little consulting from time to time and attends various trade association meetings in the electronic field; otherwise, he writes, he spends his time in Florida entertaining his grandchildren with sailing, water skiing, and food. . . . **Tom Scott** recently visited Moscow and Leningrad. . . . **Frank Kurt** says he is "marching — or tumbling — gracefully into old age." . . . **Emery Patterson**, who had lived in Maine after retiring from National Steel, moved in 1975 to "warm, sunny Arizona." . . . For those of you who have copies of the 50th Reunion picture and its accompanying list of names, here are the additions and corrections I have received so far: Front row, No. 3 is **Richardson**, not **Burger**; No. 15 is **Bearg**; No. 17 is **Parker**. Second Row, No. 15 is **Hall**, No. 16 **Miller**, and No. 19 **Tacy**, not **Kingsley**. Third and Fourth Rows, No. 8 is **Carr**, No. 12 **Heins**, No. 14 **Scott**, and No. 23, **McCabe**. Before a corrected list is distributed, would each of you take one more look and see if you can fill in any of the still-missing names.

I have, regretably, three more recent deaths of classmates to record. The sympathies of the class go out to the families of **Amos T. Akerman, Ralph Peterson,** and **Carl Redd**. **Amos Akerman** retired from the U.S. Army in mid-1955 as a Colonel, and subsequently taught at Kamehameha School for boys in Honolulu until 1965, when he moved to Orlando, Fla. The last time I heard from him, in 1974, he was living quietly in Orlando, but the death notice gives his address as Fairfax Nursing Center, Fairfax, Va.

Ralph Peterson died this past March in Wilmington, Del., where he had lived for 38 years. He had retired as a chemical engineer for DuPont. During World War II, while at DuPont, he worked as a process manager in the atomic energy program. He is survived by his wife, Alice, two sons, and five grandchildren. **Carl Redd**'s death also occurred in March, in Baltimore. He was a consulting structural engineer and was associated with many prominent buildings in the Baltimore area, including the Social Security complex at Woodlawn, the Federal Office Building at Charles Center, the Mercy. St. Joseph's, and South Baltimore General Hospitals and the Greater Baltimore Medical Center, and the Milton S. Eisenhower Library. He had also worked on the Kennedy Center for the Performing Arts in Washington, and at the Wolf Trap performing arts complex in Vienna, Va. He leaves his wife, Ruth, and a son and daughter.

In addition to the above three, I have received very belated word, through **Bill Corey**, that **Dave Powell** (D. Carson Powell) died in the fall of 1950. Dave had been a Seabee during the war, and had worked as a civil engineer on several of the New York City subways. He had been listed among our "missing" classmates. — **Joseph H. Melhado**, Secretary, 24 Rodney Rd., Scarsdale, N.Y. 10583

28

The Great 50th Reunion of the M.I.T. Class of 1928 was an outstanding success by any measure! From the first exciting arrivals on campus to the last au revoir a short five days later there was a continuity of events shared happily by everyone. Still there was plenty of opportunity to look about, reminisce, and to enjoy old and new friendships. . . . It was the largest 50-year Reunion in the history of the Institute. . . . The grand total of 244 in attendance included 133 classmates and 111 spouses (3 widows). Eighty per cent (195) chose to be housed in McCormick Hall and nearly filled that dormitory to capacity. Most of the remaining 20 per cent roomed at nearby hotels but were on hand each morning for breakfast on campus and to join in the day's activities.

From all parts of the country they came plus a good number from outside. In making the trek from Japen, **Shikao Ikehara** came the longest distance. Then from Venezuela there were Ana and **Mariano Contreras** along with Helen and **Gabe Disario**; from Greece: **John Houpis**; from Spain: **Hector Hagedorn**; from Mexico: Concha and **Pete Moyano** along with Nella and **Leonardo Siller**; and from Canada: Phyllis and **Chuck Carter** with Pam and **Rene Simard.**

Upon arriving, each registrant received a copy of the 50-year class book, souvenirs, a packet of informational items and Technology Day tickets. The souvenir for classmates was an interesting, artistic and richly beautiful laser-etched walnut paper weight showing the familiar Great Dome and Killian Court facade, and inscribed to mark the 50th Reunion occasion. For each classmate's spouse there was a very special mohair stole, hand made and dyed to match the cardinal jackets of their mates. Most of the men who had ordered jackets had them sent to McCormick where they were ready and waiting. They were worn at all the dress occasions when the ladies also displayed their colorful stoles.

To the best of our knowledge, nobody went hungry at any time. The pace was set the very first day when arriving travelers were greeted with a refreshing and tastefully arranged snack bar featuring some of the biggest and most luscious strawberries we have ever seen. From the enthusiasm and excitement of that first day one would never suspect that many of those present had just completed long and tiring trips. Nearly everyone was on hand for the Bill Carlisle Cocktail Hour and the happy hum of voices continued on through the dinner dance and well into the evening. Did anyone dance? You had better believe it! The music of the Scollay Square Stompers was mostly lively, sometimes nostalgic but all of it appropriate. . . . Because of the very large turnout, this and all subsequent group gatherings were held in the Sala de Puerto Rico at the Student Center. This meant a short walk to and from McCormick but the exercise was not unwelcome. Even the weather favored us. Wednesday was a beautiful day for the scenic bus ride to Marblehead and a New England clambake at the elegant Corinthian Yacht Club with harbor and ocean in view. This event alone could have been the high point of the entire reunion. That evening we had our Class meeting. **Jim Donovan** reported on his progress with the Class Gift, due to be presented on the Friday to come. At that time it appeared that the gift would fall somewhat short of the million dollar mark for which we all had hoped. Reaction to this somewhat disappointing situation was immediate. **Nap LaCroix** proposed that the Class resolve to close the gap at once with pledges. Jim felt that the general spirit prevailing was ample evidence of such a desire without the need for a formal vote. How right he was could hardly have been predicted! A veritable flood of contributions and pledges over the following two days carried the gift total for beyond the goal we had in mind.

Before allowing him to yield the podium, Jim was presented with an M.I.T. chair bearing a gold plated plaque expressing appreciation of the Class for his unceasing services to M.I.T. and '28 during more than a half century. The shrouded chair was carried in aloft by an honor guard, then uncovered and given to a very surprised Jim who, for once, was speechless. For the rest of the evening we were entertained first with old student day songs by a '28 chorus **Bob Harris** had organized and led by him with the able assistance of **Pete Kirwin**. Warren Seamans, Director of the M.I.T. Historical Collections, showed and narrated some very old M.I.T. movies. Following this we saw some ancient movies taken at earlier '28 reunions beginning with the 5th. The final film was an interesting documentary production on Venezuela thoughtfully provided by our classmates from that country.

Thursday was another very full and pleasant day. We were bussed early to the new Boston Waterfront where each went his own way during the morning to browse, shop or enjoy an exhibit. For lunch we gathered at the waterfront Stella Restaurant where a two-hour Italian-style meal was served and the red wine flowed without stint. Then it was back to the Institute to dress for the evening. From McCormick we were taken by bus to the President's House where we were graciously received by President and Mrs. Wiesner. Following cocktails and a buffet supper we were bussed directly to Symphony Hall in Boston for a wonderful evening at Pops with Arthur Fielder as conductor. Our group occupied nearly a third of the center table section on the lower hall floor and made an impressive sight with all the red jackets and stoles. Back on campus and before retiring, two practice sessions were held so we could give a proper cheer next day at the luncheon.

Friday was a big day. The Class joined others of the M.I.T. alumni family for scheduled events of Technology Day, including breakfast, memorial services, talks and the annual luncheon meeting in Rockwell Cage. By tradition, the day's high point is when class gifts are presented by the 25-, 40- and 50-year classes. This year the newest class, M.I.T. '78, also presented a gift. This inspired an anonymous '28er to direct that a substantial portion of his gift be applied to the '78 project.

Jim Donovan made an excellent presentation speech for '28 and, with obvious pride, was able to announce a total of $1,225,000 as the Class Gift. On signal the entire class rose and, led by **Pete Kirwin**, gave a Tech cheer that must have shaken the trusses of Rockwell while the mass of red jackets and waving red stoles made a spectacle long to be remembered.

For Florence, Friday was an especially big day. At the luncheon it was announced that Florence Jope Smith had been elected an Honorary Member of the M.I.T. Alumni Association in

recognition of her loyalty and effective services to the Institute during nearly fifty years. This was a bombshell! — A total surprise. However, she managed the trip (escorted) to the podium and was even able to express her appreciation. In the afternoon on that same day a new crew coaching launch was scheduled to be christened the "Ralph T. Jope II". This launch, a catamaran, was the gift of the Jope family and named in honor of Ralph, our Class President from graduation until his death in 1965. Ralph's granddaughter, Elizabeth (Beth) McNamara (who was just one day short of nine years old) did the honors with full dignity. Then burst the second surprise of the day! A beautiful new racing shell had been brought out — one especially designed for women's crew. As Florence, her family and the assembled company watched — the "Florence Jope Smith" was unveiled! With her newly acquired experience, granddaughter Beth had the honor of christening this boat also. The day ended with a dinner in honor of faculty guests after which "Doc" Harold Edgerton gave one of his interesting talks illustrated with movies and spiced with humor.

Our last full day, Saturday, was pleasantly educational. The morning was spent at the fascinating M.I.T. Historical Collections where, in addition to exhibits relative to M.I.T. and early days of science and engineering, Warren Seamans had a special exhibit featuring photographs and other material pertaining specifically to the Class of 1928. Many classmates found items there that were of direct personal interest. . . . After lunch an informative and thought provoking talk was given by Dr. Robert Suskind, Associate Professor in the Institute's Department of Nutrition and Food Sciences.

A private viewing that evening of the world famous Pompeii AD79 exhibit at the Boston Museum of Fine Arts was the crowning event of the week. It gave us much to think about. The museum visit was concluded with cocktails in the Sculpture Garden and dinner in the Gallery Dining Room overlooking the garden. Jim Killian '26, our MC, introduced our speaker, Dr. Jan Fontein, Museum Director, who had arranged to have the fabulous Pompeii exhibit brought to this country.

Sunday was the day of exodus and it appeared that nearly everyone had gone the full distance. Yes, it was a wonderful reunion and made possible by the enthusiastic spirit of '28 and the many individuals who gave their time, energy and talents to the project. The names and deeds of the latter must be reported but can only be done in our next set of Notes since we have now run out of space for this issue. — **Walter J. Smith**, Secretary, 37 Dix Street, Winchester, Mass. 01890

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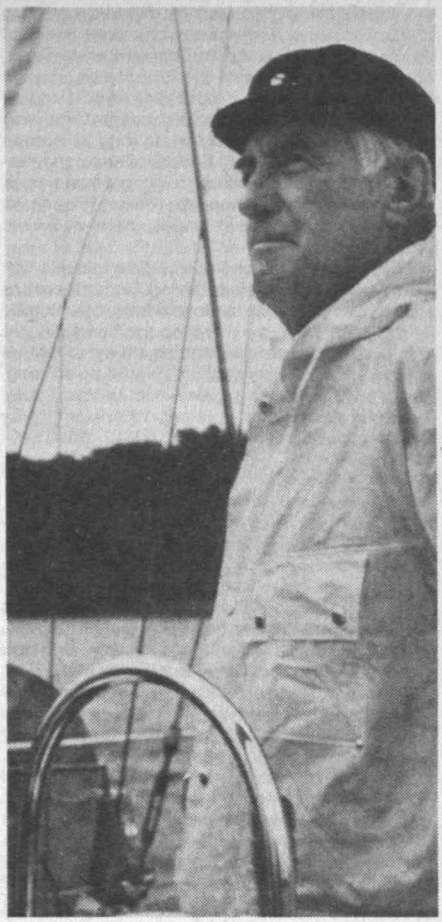
A post card from **Hunter Rouse** came from Taipei in April: "Since late March I have been giving a series of lectures as guest of a former graduate student, now President of National Taiwan University." Since our class notes are not exactly "Instant News," we also have a follow-up note: "Doi brought your much-appreciated birthday greetings here to Kona to greet me on my way back from Taiwan." . . . **Robert S. Riley** has been officially retired since 1971, though he worked three days a week doing research in powdered metals until 1973. He has done quite a bit of traveling since his retirement, visiting Egypt, Scandinavia, the Greek Islands, the Mediterranean and Black Seas and Antarctica. Last October, he saw the eclipse of the sun in the middle of the Pacific Ocean. He is very active and adventurous — he is planning a hot-air balloon trip in France with Buddy Bombard, and goes skiing every winter. He and his wife Marnie boast eight children and 21 grandchildren. . . . An announcement, dated March, 1978, comes from **Fred Celler** and his wife Margery: "After 17 years of activities and residency in France, we have now established our permanent residency in Florida. Following two months of wide search and much deliberation, we have purchased a condominium apartment in Central Florida, near Orlando. It is small but comfortable, on the ninth floor, at the edge of Winter Park overlooking Lake Maitland. Our new address is: 'West Cove,' Apt. 903, 1100 South Orlando Ave., Maitland, Fla. 32751." Fred and Margery attended our 40th at the Wiano Club, coming from France. . . . **Willis F. Davis** has been retired from G.E. since June, 1970, and he is greatly enjoying his leisure hours. . . . **Nathan Promisel** was recently elected to the National Academy of Engineers, the highest national recognition for engineers. He has been President of the American Society for Metals and President of the Federation of Materials Societies. . . . A note from Brig. Gen. **James E. Howarth, Jr.**: "Retired from the Marine Corps Reserve and F.A.A. in 1966. Could not stand the idle life, so I have been engaged in real estate business since 1967. Presently I am associated with 'Carriage House Associates, Inc.,' in Arlington, Va."

Received a note from **Bill Bowie**: "We have had a good winter with a little travel south and a few days in Guatemala with some interesting experiences. Hope you and Helen have wintered well and survived the crowds we understand have overwhelmed Fort Lauderdale-Pompano Beach area this winter — such stories don't do much to encourage us to go there. We enjoy the quiet of our mountains, even though it is cold. From all reports, the 50th is coming along well and from my view, the fund is building nicely." (Bill is our Class Agent.) . . . **John G. (Jack) Sullivan** writes, "Retired six years ago to the Cape, and I seem to be busier than when I was working for a living. I took one short break for a consulting job in Rio, but essentially we have stayed on the Cape, other than winters (February and March) which we spend in Georgia. I became involved in the government study committee for our town (East Dennis) and do volunteer work at the Cape Cod Hospital. I manage to play some golf, work around the house and garden and I have satisfied my life-long ambition to read the *New York Times* at my leisure (which does not generally come before 10 p.m.). I am looking forward to seeing you and the rest of the 'troops' at the 50th."

John D. McCaskey is plugging along in his studies at the University of Montana towards his Ph.D. in history. Most likely we will be addressing him as "Dr. McCaskey" at our 50th Reunion. . . . **Stephen N. Dilworth** was smart in courting his present wife Myn at our 45th Reunion and marrying her shortly thereafter. He not only got himself a free housekeeper and a cook, but a private secretary as well. "Steve's secretary" writes, "Greetings from Indian Rocks Beach! We have been here in this delightful cold weather for three months (since December) and we hope to head for North tomorrow. We have now become residents of Florida, having purchased a condo in Largo. We have one little problem: we have to sell our condo in Rossmoor, N.J., or we will own two condos, two sets of furniture, etc. Everyone advises to just take purse and toothbrush when moving South, and we have listened."

While sending **Ted Malmstrom** a birthday card, I asked, "Are you in Hawaii?" Florence answers, "Yes, we are in Hawaii; have been here since December 1, after a two-week stop-over in Chicago, where it was cold with plenty of snow. This may come to you as a surprise but we are seriously considering moving here permanently, which may or may not interfere with our attendance to the 50th Reunion. I don't think we can face the New England winters any more. We have no reason to settle in Florida as some do — our children and grandchildren who are our main interest and concern at this point in our life are far from Florida. We'll definitely keep you informed of our decision." . . . I have a note from **Richard Piez**: "I don't know how you do it, but it is wonderful that you have the time and the interest to keep us all informed and keep the class members together. We are giving some thoughts to taking a trip to Europe this spring. No other plans or project beyond that at this point. Best wishes to all." . . . **Arnold Conti** writes: "Thanks for the Happy Birthday from the Class of 1929 — I can always depend on you and form 1040 not to forget me. Last year was a busy one for me, as I was involved in construction and banking projects in Massachusetts



For the first time in 17 years, John J. Wilson, '29, Secretary of the Corporation, was not in his customary spot as Marshal of the Corporation in the Commencement procession on June 5: he suffered a heart attack the day before. John was scheduled to depart three days later to pick up his Danish-built ketch, Holger Danske, *in Sardinia for a summer of cruising around Corsica, Elba, Sicily, the Greek islands and along the Adriatic coast of Yugoslavia. He had sailed the boat from Marblehead to Gibraltar in the summer of 1977, thence through the western Mediterranean to Sardinia; the round trip was to be completed with a passage this fall from Malta-Gibraltar-Canaries-Barbados and a final leg Barbados to Marblehead in early summer of 1979; it would have been John's third transatlantic round trip as skipper-navigator on his boat. The earlier passages took him to Spain, Portugal, Morocco, the Azores, Madeira, Dakar, the Cape Verde Islands, and the various Caribbean islands. He has also cruised in the Baltic with* Holger Danske, *visiting Denmark, Sweden and Finland. John is now making a good recovery and looking forward to having his son, Richard, S.M. '76, take his place as skipper/navigator to sail the boat back to Barbados this fall.*

and Florida. We managed to leave Massachusetts four days before the heavy snow storm in January only to find a slightly warmer Florida, with rain instead of snow. For lack of something better to do, I entered a Seniors' Tournament at Pt. Clear, Ala., and backed into first place. It was so cold there that many of the old boys stayed huddled around the fireplace, so the competition was scanty. It was quite satisfying so long as no one asks, 'How did you do it?' Both sons and daughter-in-law are back in school doing graduate work and both Mary and I hope that they will soon be propelled towards that nefarious gray area known as 'earning a living.'"

The response to the Reunion Committee's first mailing was more than gratifying. So far there are 128 replies of which an overwhelming majority indicate that they are planning to attend. (Just a little over 20 per cent answer that they cannot.) If you have not mailed your card, please do so soon. This should be our Big Event — let us make it so. — **Karnig S. Dinjian**, Secretary, 10 Ancient H'way at Plaice Cove, Hampton, N.H. 03842, (603) 926-5363

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Recent rummaging through the desk drawer in which I keep the materials relating to my secretarial duties, brought the discovery of two news items that were received earlier this year but were apparently mislaid. My apologies to **Don Harrison** and **Joe Harrington**, the classmates involved. Don retired some years ago as general patent counsel of Union Carbide and he and his wife Mary are now living in Roxbury, Conn. He is a member of the Roxbury Planning Commission, Vice Chairman of the Northwestern Connecticut Regional Planning Agency and president of the Washington, Conn., Art Association. . . . Joe retired from Arthur D. Little, Inc. in mid-1970 but continues to do consulting work and maintains an office at A.D.L. At the time of his retirement he was head of the mechanical engineering department of A.D.L., engaged largely in designing automatic production machines and mechanical products, as well as the relevant manufacturing systems. Over the years his field of specialization has changed as the industrial world has changed. He is now working principally in the field of computer integrated manufacturing; and even more narrowly, in the manufacture of mechanical and electronic products known as the "discrete parts manufacturing field" to distinguish it from the process industries. A major part of his work for the last two years has been as an expert witness in anti-trust cases.

His book, *Computer Integrated Manufacturing*, on which he was working at the time of the last report in the Notes, has been completed and is enjoying a brisk sale, both as a reference text and as a school text. Joe says he frequently meets someone who says "I have your book and have found it most helpful. Now I want to ask you for some further help. . . ." For many years Joe has been a member of the Numerical Control Society, which is a society of professional engineers working in the field of computer-aided manufacturing, and served as its national president in 1970-71. He is also a member of the National Research Council, Academy of Engineering committee on computer-aided design and manufacture.

Joe has held elected or appointed offices in his hometown of Wenham for more than 40 years, including five years as Selectman, and 21 years as Town Moderator. He has written a monograph on "The History of Town Meetings as a Form of Local Government" and is a member of the Massachusetts Moderators Association and its president for two years. The Harrington's three children are married and together with their spouses hold five doctorates in such diverse fields as medicine, history, nuclear engineering, clinical psychology and choral music.

As previously published in the Notes, **Langley Isom** retired some years ago from Reeves Bros., Inc. in New York as manager of new product development and he and his wife are now living in Yarmouth Port, Mass. He has previously worked for Dewey and Almy Chemical Co. in Cambridge, and Heveatex Corp. in Melrose, Mass., also in new product development. Langley continues to list cruising under sail as his principal hobby. . . . **Rudolph Israel** did his undergraduate work at Stanford and then came on to M.I.T. to obtain a master's degree in civil engineering in 1930. He has since worked for the California Highway Department and is presently Assistant State Traffic Engineer in charge of operations and traffic safety and signing for the entire state. He is a fellow of the Institute of Traffic Engineers and in 1974 received the "Outstanding Service to Engineering Profession" award of the Engineering Council of the Sacramento area. Rudolph is active in the Eagle Scout Association of the B.S.A. and received the B.S.A. Silver Bear award in 1968. The Israel's son Richard is an entomologist and the author of the *Homesteader's Handbook* which is now in its third printing.

Bill Jackson is also a scouter, a member of the Executive Board of the B.S.A. National Council and the recipient in 1972 of the Silver Buffalo Award. He is still active in business as Chairman of the Board and Chief Executive Officer of Pittsburgh-Des Moines Steel Co. whose business is construction projects. Their most interesting project in recent years has been building the St. Louis Arch. Bill's directorships include the National Association of Manufacturers, Pittsburgh Theological Seminary, and Dollar Savings Bank.

We have at hand some delayed notices concerning the deaths of three of our classmates. **Albert Nault** on April 14, 1975; **Norman Smith** on June 26, 1976; and **Bob Sidur** on December 31, 1977. Unfortunately, I have no information at all concerning Albert's activities since graduation. Norman Smith worked for a series of companies, including the Foxboro Co., Manning Maxwell and Moore, Crosby Steam Guage, Fenwall Inc., Staico Corp., American Meter Co., Leeds and Northrup, Philco and J. E. Lannigan Co. Also he worked as a research associate at M.I.T. during World War II under Dr. Draper on the gyroscopic anti-aircraft gun sight. My most recent information is based on a 1970 report, at which time he was working for Boeing in Everett, Wash., on fire safety requirements and propulsion test requirements for what was then the new Boeing 747. The address I have for him in Malvern, Penn., suggests that he may have been living with his son William at the time of his death.

Bob Sidur retired from Western Electric several years ago but continued to engage in a number of business activities including a trusteeship in several large trusts and numerous smaller ones. He did consulting work for banks in connection with investments for these and other trusts and was president of the Seabrook Housing Corp. and of the Nan Realty Corp. He was also a member of the Board of Governors and past Treasurer of the Maplewood Country Club. Several years ago he listed his hobbies as including photography, fishing, hiking, inventions in the field of sound, optics and navigational aids, reading, travel, boating, numismatics and gold. My records indicate that he was living in Chatham, N.J., at the time of his death and is survived by his wife, Thelma, and several stepchildren. — **Gordon K. Lister**, Secretary, 530 Fifth Ave., New York, N.Y. 10036

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Don Loomis writes, "Mandatory retirement terminated my business career four years ago; but it has also opened the door to opportunities for community service which have proved so stimulating and satisfying that we have neither time nor desire for travel. Betty and I have been blessed with continued good health for which we are most grateful." . . . **John McNiff** says that he hopes the Alumni Association will see that his name and address are returned to the roster of the M.I.T. Club of Southwestern Maine so that he will get timely notices of meetings. . . . **Al Sims** reports that he and Lillian made a trip to Hawaii in January with an Audubon Society group and are now saving towards the 1979 Mexico Fiesta. (Hope to see you and Lillian there, Al — Ed). . . . **Francis Weeks** and his wife find world travel very enjoyable in his retirement and mentions that they have just returned from their second trip to India including the first trip to Bhutan. . . . **Art Fuller** is still guiding his corporation, Fuller System, Inc., in Woburn, celebrating his 50th year. Art is now semi-retired but still developing new products used in greenhouses for insect and disease control. He is already looking forward to the 50th reunion. . . . Since retiring from Sun Oil Co., where he was Director of Marketing Research, **Arnold Childs** and Rita have made several trips on freighters. They now spend six winter months on Siesta Key, Fla., and summers in New Hampshire. They have a son living in Rye who works for Metropolitan Life and another teaching and doing missionary work in Nigeria. In addition, they now have five grandchildren.

John Dodge reports that he is retired and a permanent resident of Florida, but he's still active as a member of a group of authors that work on the physics texts which originated 20 years ago in M.I.T.'s Physical Science Study Committee; at the time these notes were written he was in Boston preparing (in company with fellow authors) the fifth edition of *PSSC Physics*. John comments, "You can be sure I will return home to Florida before winter sets in — none of your New England winters for me!" His temporary address is 38 Cummington St., Boston, Mass. 02215 and home address is 06B F. Minnesota Ave., Deland, Fla. 32710.

A letter and clipping from an old prep school classmate, Syd Palmer, from the front page of the *Portsmouth Herald* for May 19, 1978, tell that **Wyman Boynton** received the 1978 Community Service Award from the Greater Portsmouth Chamber of Commerce. Wyman and Mildred's pictures appeared on the front page receiving the award. Apparently it was a complete surprise to Wyman who thought he was attending the function as a regular guest.

It is with sadness and sincerest condolences to their families that the deaths of the following classmates are reported: **Daniel Calkin**, March 2, 1978; **Walter Gompertz**, January 4, 1978; **William Kimball**, March 17, 1978 (Bill was formerly Dean of the Thayer School of Engineering at Dartmouth College and an internationally known educator); and **Joe Shimek**, March 10, 1978 (Joe died of a massive heart attack just as he finished a lecture to graduate students at Rice University). — **Edwin S. Worden**, Secretary, P.O. Box 1241, Mount Dora, Fla. 32757; **Ben W. Steverman**, Assistant Secretary, 260 Morrison Dr., Pittsburgh, Penn. 15216; and **John R. Swanton**, 27 George St., Newton, Mass. 02158

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Alumni Day, June 9, was a beautiful June day and it gave me the opportunity to meet with several of our classmates. Among those in attendance were **Wendell Bearce**, **John Brown**, **Melvin Castleman**, **George Daniels**, **Douglas Miller**, **Albert O'Neil**, **George Sistare, Jr.**, **Charles Taylor**, **Harold Tonsing**, **Thomas Weston**, and **Don Whiston**.

A very meaningful memorial service for M.I.T. Alumni was conducted at the M.I.T. Chapel by Father Robert Moran, C.S.P. The members of the Class of 1932 reported deceased from May 1, 1977, to May 5, 1978, are as follows: **William P. Cantono**, **Theodore A. Chadwick**, **H. Archer Clark, Jr.**, **Joseph E. Coffey, Jr.**, **Theodore J. Jones**, **Frederick E. Mader**, **Martin T. Meyer**, **James E. Paige**, **Erskine G. Roberts**, **George T. E. Sheldon**, **William F. Spreen, Jr.**, **Alva T. Wilson**.

I had a good opportunity to have a talk with Maxine and **Wendell Bearce**. Wendell was with Consolidated Coal for 25 years until January 1, 1975. He holds several patents on a thermo dryer for fine materials — principally coal. He is at present very actively engaged in his own company, W. E. Bearce Co. — a sales and engineering company specializing in coal preparation, material handling, and fine coal drying. His youngest son Peter is working with him. Wendell

and Maxine have six children, five grandchildren and two great-grandchildren who have just been born. They will see them for the first time this week. Their hobbies include golf and bowling. They attended the M.I.T. Aspen seminar which they enjoyed very much.

George Sistare, Jr., came up for the day from Fairfield, Conn. He retired four years ago from Handy and Harmon. He was a research metallurgist specializing in silver and gold alloys. What does he do now? Plenty! He does consulting work four days a month. He builds and sells modern style cabinets, and then as time permits he repairs fibreglass boats. . . . **Jim Harper** writes us of some sad news. **Robert R. (Andy) Anderson, Jr.**, of Springfield, Va., was found to have cancer of the brain. Sometime after the operation he died, in September, 1977. He leaves his wife Henrietta and a daughter who is receiving a graduate degree in music this year. Andy had retired from the civil service and was practicing patent law. Henrietta has renewed her interest in the Mayflower Society. . . . **Jim Harper** also reports the death of **Dwight Ashley** of Alexandria, Va. He died in October, three months after he had been diagnosed as having bronchial cancer. Dwight was a retired government civil servant and had been concentrating on contract bridge and golf. His wife Gertrude remains in the home and spends much time with the many nieces and nephews and godchildren.

I'll have more to say in the next issue about those I met on Alumni Day. All for now. — **Melvin Castleman**, Secretary, 163 Beach Bluff Ave., Swampscott, Mass. 01907

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By my count we had 60 classmates at the Reunion, most with wives — Sarah and **Jack Adelson**, Jerlain and **Jack Andrews**, Georgie and **Bill Barbour**, Clare and **Bill Baur**, Agnes and **Al Bowen**, Jo and **Ray Brown**, Marie and **Charlie Cashman**, Louise and **Ellery Clark**, Jean and **Dayt Clewell**, Marge and **Bob Crane**, Mabel and **Quimby Duntley**, Helen and **Bob Forbes**, Charalee and **Dick Fossett**, Suzanne and **Paul Genachte**, Ellie and **Roland Glenn**, Elizabeth and **Leo Goodman**, Nancy and **Bill Gray**, Ruth and **Art Hayden**, Leona and **Warren Henderson**, Lucy and **George Henning**, Kay and **Allan Hinkle**, Ruth and **Neil Hopkins**, Dot and **Bill Huston**, Helen and **Art Hungerford**, Alice and **Ferd Johnson**, Doris and **Len Julian**, Dot and **Gerry Kincade**, Peg and **Gus Liljegran**, Roslyn and **Ellis Littmann**, Marge and **Prentiss Lobdell**, Lillian and **John Longley**, Jean and **John MacIsaac**, Althea and **John McAleer**, Ellie and **Mal Mayer**, Nancy and **George Maynard**, Laura and **Ivor Morgan**, **Meredith Morgan**, Miriam and **Niazi Mostafa**, Marian and **Dick Morse**, Anne and **Fred Murphy**, Flo and **Paul Netherwood**, **Don Newhall**, Fran and **Tom Newton**, Betty and **Al Payne**, Esther and **Steve Rhodes**, **Robinson** (no initials — our class has two of this tribe, **Dick** from Boston and **Sam** from Texas: I'm inclined to think it's Dick, but. . . . I would like to know, by early September), Anne and **John Rumsey**, Eileen and **Dick Smith**, **Bill Soley, Jr.**, Delphine and **John Sterner**, Elizabeth and **Joel Stevens**, Jane and **George Stoll**, **Ed Simpson** with wife, Marie and **Olavi Viita**, Do and **Stan Walters**, Elenora and **Warren Webster**, **Westy Westaway**, Wilma and **Bob White**, Daphne and **Beau Whitton** — this is everyone who came to Chatham Bars Inn. Quite a few attended the Pops and the annual Luncheon too; the **Courtenay Marshalls** did take in the Pops but I didn't see them at the Luncheon. The committee (**George Stoll**) didn't check attendance at the Luncheon, so I suggest that any of you who did attend — either Cambridge or Cape Cod — if your name is not listed please drop me a line at the Fort Rock address (which now holds good the year around).

Extra, Extra! New Class Officers Elected at Chatham — President: **Ellis C. Littmann**; Executive Vice President: **Frederick V. Murphy, Jr.**; Treasurer: **George Stoll**; Secretary: **Warren Henderson**; Regional Vice Presidents: **Clarence R. Westaway**, **George Henning**, **Courtenay D. Marshall**, **Calvin H. Mohr**, **Beaumert H. Whitton**. The two top officers are well-known as real executives; and your present officers are well aware that sudden vacancies can occur at our age so we have a few others in mind fully capable of carrying on in case too much attrition catches up with us. Your class is in good hands as may have been noticed at the 45th — a smoother job I've seldom seen. And most of those to whom I talked thought that the 45th was the best ever (which speaks right out loud for a fine 50th).

I have a few observations in connection with the 45th: During our seven previous reunions, it appears that many of our fellows got acquainted with members of other courses and found out these fellows are normal humans, just like their old coursemates — and they found out that there are many classmates they never saw before this reunion stuff got going. So now many of us have become reunion addicts and we just naturally show up when there is one scheduled. I recall the 5th Reunion, at the Norwich Country Club — there might have been 30 to 35 men there (no wives); I knew very few but it was a good start. And by the eighth successive reunion that I have attended I know most classmates but well. Perhaps that is why the 45th was the best ever.

I have a short letter from our new President, Ellis the First, in which he inquires just who the new offices are — especially the five Vice Presidents. . . . **Cal Mohr** mentions that **George Garcelon** visited him at his home and spent most of a day with him in early June. . . . I have one of my few "goof" letters, from **Bob Olsen** of Winter Haven, Fla. Yes, Bob, I did goof, and somehow misinterpreted your message: the May *Review* had a story about Bob spending a lot of time with the Florida migrant workers. Turns out that ain't so; Bob spends no time with these fellas. I also wrote that Bob and his wife are members of the Church of the Brethren, which, too, is not so. I do know that I quoted from a message, but that's all I can remember. One thing is sure: I do NOT make up any of my manuscript. But I do apologize for the error, sincerely — this was a crazy error.

Walt Skees sends a prospectus and several nice pictures of his home in Madrid, which is for rent. The estate is two houses on ten acres of prime land, both 14" native stone. The rent: $500.00 per month, but only to M.I.T. men. The estate is in the suburbs of Madrid and is mostly self-sufficient, with its own good water and 220 volt AC power. This sounds like a good deal, though why limited to M.I.T. men is not clear. Oh, were I only 45 and know what I know now; thanks Walt, and I'll keep the prospectus and photos for acting as agent.

I have a fine note from Dave Hollidge '35 — he spent an hour or so recently with **Tom Fitzpatrick** in Savannah. Tom is one of my favorite correspondents, so it is nice to hear about him. Tom could spare little time for Dave, as his wife had recently been through a bout of major surgery; she is quite cheerful now and is looking foward to some tennis very soon. That gal has a most delightful southern accent, though I have not met her but spoke with her by phone. Thanks for the good letter, Dave, I wish you were in our class — we need more good correspondents. . . . I have a nice note from **Tom Galvin** who suffered a massive stroke a couple of years ago and is making some progress — he can walk now with the aid of a cane. But there is apparently a long road ahead. Rita shows what a real true blue gal she is by being an enormous help to Tom, but even she is slowly being taken over by arthritis. Obviously Tom could not make the 45th. Lots of best wishes to a pair of good troopers that are lovely people — best of luck to you both from your class.

I was surprised to get a letter from **Emmy Norris** upon my arrival at Chatham Bars Inn. You will recall that Emmy suffered a massive stroke several years ago and has been doing a valiant job of recovery. Emmy wrote to say that his attendance at the 45th was pretty much out of the question. Although he has made a lot of progress, he thought it would be better not to attempt the trip and the two nights of rather strenuous activities. We are sorry you could not make it — several fellows asked about you, and I showed your letter. Good luck and best to you both.

One Alumni Fund Capsule this time, from **Gerard Kincade**; "Mrs. Kincade and I have just returned from a six-months' assignment with the International Executive Service Corps in the Phillipines, where our client was the Paper Industries Corp. of the Phillipines." I saw Gerard and his good wife at the 45th and he did not mention what he was actually doing for such a long time.

There are no reports of any classmates passing to their reward this time around. That's a healthy condition and we can use a lot more of it!

My very best to all those loyal classmates who attended the 45th. Far too many spent too dang much time finding something else to do. Best regards to all our readers and good health to every classmate, wherever you are. — **Warren J. Henderson**, Secretary, Fort Rock Farm, Drawer H., Exeter, N.H. 03833

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This must unquestionably be the most disheartening set of notes I have had to write — it contains almost entirely word of the loss of classmates. What is worse, some go back much too far; somehow the word should have gotten to us.

To begin with the most personally distressing is the bare notice from the Alumni office of the death in October, 1976, of **Rene DuBois**. I know nothing beyond that and it comes as a real shock, as he was one of the group with whom I was extremely close. We all had rooms on the same floor in Monroe, went over to Boston every night to some of the tea rooms that abounded then, and double-dated to many dances. It's been years since I last saw him — he had retired to Naples, Fla. — but it was one of those relationships that could be picked up again on sight.

Another classmate I knew quite well was **George Fickett**. He died here on the Cape in May, and regretfully I did not see his obituary until after the funeral services. Since 1973, he and his wife Dorothy had lived in Venice, Fla., after leaving Centerville. During his business career he had been New England manager and then Vice President and General Sales Manager for the Powers Regulator Co. in Skokie, Ill., after retirement from Powers in 1965 as a management and engineering consultant for various New England companies. He was both a registered professional engineer and a life member of the American Society of Heating, Refrigeration, and Air Conditioning Engineers.

Joseph Daleda was the victim of an unfortunate accidental drowning at Port Charlotte, Fla., in January, 1977. He had been living there with his wife Harriet since he retired from Texaco Development Corp., where he had been a patent attorney since the mid-1950s. Joe had started working as an examiner with the U.S. Patent Office in the late 1930s while attending George Washington University. During World War II he served in the Army Air Force, attaining the rank of colonel. After the war he returned to the Patent Office where he stayed until his move to Texaco. During the post-war years he remained active as the commander of an Air Reserve Group in New Jersey.

Our final immediate loss is that of **Edward S. Coe, Sr.**, of Detroit who died on January 4, 1978. He was a retired department head and metallurgical engineer for Ford Motor Co. Obviously his hobby was bridge as he was a duplicate life master. He leaves a wife Harriet, a son and daughter, and six grandchildren.

To bring this depressing litany to a close, Florence Jope Smith, whose husband is Secretary of the class of '28, sent me world of the death of Roberta Nowell of Winchester, Mass. Her late husband **Edward Nowell** had been a member of our class.

I have not tried to list all the survivors of our lost classmates — I can only extend sympathy on behalf of all of us to them.

News of a more cheerful tenor is sparse but it will serve to finish on a more hopeful note. One great Alumni Fund memo from **Bernard Stiller** just says "Retired." Well, since it means he sent money with it, I'll forgive his rambling on so! . . . In

another Fund note, **Wolfgang Rahles** writes, "Have been retired for one and a half years. Still doing consulting for Ashland Chemical but not overdoing it. Play a little golf when possible but this past winter did not allow much of that."

From **Cassius Belden**, of Lansdown, Canada (I suspect in the Montreal area) comes information that he is retired as Vice President for employee relations at Dominion Bridge Co., Ltd., and expects to do some personal (maybe also "personnel"?) consulting from his home under the name of "Organization Resources Consultant."

A final clipping was way out of date by the time I got it. It announced that **Larry Stein** was running for his second three-year term on the Hingham municipal light board. This is a field he has been active in for some years, as well as six years on the school committee. Well, we found out at the Reunion Committee that he made it — there was some suggestion that he was offering special rates to people who would vote for him but he says that was just a dirty lie.

Speaking of the Reunion Committee, you should have gotten our first mailing about the occasion. If the idea of staying in Cambridge doesn't send you at first, you should see the lists we got of what the classes meeting at M.I.T. will be doing. And if you haven't been around Boston in the last few years, you ain't, as the saying goes, "seen nuthin' yet"! So save the dates, we're predicting a blast. — **Robert M. Franklin**, Secretary, 620 Satucket Rd., (P.O. Box 1147), Brewster, Mass. 02631; **George Bull**, Assistant Secretary, The Elizabeth, 4601 N. Park Ave., Apt. 711, Chevy Chase, Md. 20015

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It can now be reported that the concensus of the Reunion Location Committee, and those attending the mini-reunion dinner June 9 is that the 45th Reunion be held in the Berkshires. **Bernie Nelson** and **John Taplin** will have more to report on this later. Also, it has been decided to forego a mini-reunion next June because there will be inumerable organization meetings during 1979 for the 1980 Reunion.

Twenty-seven hardy golfers are teeing off in our 18th Annual Class Golf Tournament and at this stage optiomism is high. Thirty-fivers from as far away as California, Colorado, Minnesota, Texas, Arkansas and Florida are facing the "locals": New England and Mid-Atlantic States. We will keep you informed.

Those attending the mini-reunion dinner at M.I.T. on June 9 included: **Rufus Applegarth**, **Randy Antonsen**, Betty and **Leo Beckwith**, **Ned Collins**, Sarah and **Phoenix Dangel**, Julia and **George Forsburg**, Connie and **Bob Forster**, Ruth and **Al Johnson**, Ida and **Macklen Kleiman**, Doreen and **Allan Mowatt**, Rhoda and **Bernie Nelson**, Ginny and **John Taplin**, and Evelyn and **Vinton Ulrich**.

Bissell Alderman has resigned as Trustee of the Vanguard Savings Bank of Holyoke after 29 years on the job and is moving to Jaffrey, N.H. He was unanimously nominated as an Honorary Trustee, a position to which he must be elected at the bank's annual meeting in December. Let us hear from you, Bissell, with all the details.

The following notes were received through the Alumni Fund Office: **Blake D. Mills, Jr.**, writes, "Retired after 31 years as Professor of Mechanical Engineering at the University of Washington. Still playing handball with former colleagues." . . . **George C. Dunlap** writes, "Retired except for raising 25 acres citrus. Spend summers at Rand, Colo., winters in Texas. Wife Grace and I are active ham radio operators. We have two sons — one, M.I.T. '67, and two grandchildren. Hobbies — mountain climbing and fishing."

From **Jack Holly** (as exuberant as ever) "1977 was great. I retired, I remarried and acquired my 14th grandchild. However, 1978 has started off with three universe-shaking events: California got its water back, the taxpayers revolted (Proposition 13) and old Jack scored on the Options Market. Needless to say all portents are up; nothing in view but success and no doubt I'll lose another 15 pounds and be able to do the Polka one more time."

I am a little depressed to have to report to you the deaths of six of our classmates. One was **Robert S. Carr** who died June 24, 1978, and was a good friend from my Course VI classes. . . . **Henry L. Blatner**, a Course IV man, died on Feb. 3, 1978; **Arthur S. Hamilton, Jr.**, Course II, lived for a number of years in Rochester, N.Y. and died there Sept. 23, 1977; **Edward P. Champam, Jr.**, died in Albuquerque, June 21, 1977; **Henry P. Parker** died in Danforth, Maine, on Nov. 15, 1977, and **David U. Sullivan** died in Belmont, Mass., on August 30, 1976. I am sending our deepest sympathy to the surviving widows and families.

After three years of struggle and strain things are looking up at Theta-J (Solid State Relays) and we have finally moved into the black as we start our fourth fiscal year. I do little traveling these days outside the immediate Boston area as our Technical Director/Inventor/Chairman Edward T. Rodriguez is best equipped to talk to our selected customers about their problems in solid state circuitry. We have also been joined by Perry Harris as Vice President and Chief Financial Officer after he had a rocket-like seven-year career turning First Data into something worthwhile. It just happens that A.Q.M. is highly organized, knows where most everything is or can be obtained, and runs a tight ship while keeping the home fires burning. I miss my forays into the hinterlands playing golf with '35ers in between sales calls. Just the same, it is a very promising and exciting situation to be invovled with. Retiring is just about the furthest thing from my mind right now. Hey, how about writing me a letter. — **Allan Q. Mowatt**, Secretary, 61 Beaumont Ave., Newtonville, Mass. 02160

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At Alumni Day festivities in June at least a dozen class members were in attendance. At the luncheon I sat with Vivienne and **Eli Grossman**, Lillian and **Larry Peterson**, **Dick Halloran** (in from San Francisco), and Florence and **Ben Cooperstein** with their daughter Barbara. From some of them I learned that Rose and **Ed Dashefsky**, Rosalie and **Jack Chapper**, and Fran and **Leo Kramer** had attended the Pops Concert the evening before. Also listed as attending were **Charles Evans**, **Herb Metten**, **Bill Rousseau** and **Milner Wallace**. . . . The next day as I lunched at the Howard Johnson on Soldiers Field Road I spotted **Bob Woodward**. He reports that he is dividing his time between Harvard and the Woodward Research Institute in Basel, Switzerland — the research is in antibiotics. Bob said he did not anticipate retiring because he is doing exactly what he wishes to do.

Mary and **Fred Assmann**'s daughter Susan is attending graduate school at the Institute this fall with a handsome fellowship from the Bell Labs. To me the surprising part is that Susan did her undergraduate work at Dartmouth. After all, women students have been around M.I.T. for a long time — even in pure mathematics. . . . **Paul Robbins** participated as a speaker at a conference in Florida last spring. The meeting was sponsored by the Engineers Joint Council to make recommendations to implement goals of the engineering profession. . . . **Ham Migel** reports from Charlestown, R.I., that he and Barbara were settling down after a 10,000 mile drive in a motor home to Yucatan which they found fascinating. They also enjoyed some fine swimming and snorkeling. Since they live on the shore they expected a summer invasion of six grandchildren.

It is my sad duty to report the death on May 12 of **John Bete** in Marion, Mass., after an illness of several months. John divided his time between Bete Fog Nozzle, Inc., in Greenfield, Mass., and the Marion Boat works and Bete Manufacturing Co., also in Marion — an outgrowth of a small sailboat manufacturing plant John operated in the middle 1930s which produced the "Bete-About" class of sailboats, sail battens and related marine hardware. He loved boats and the water and wrote to me that he had enjoyed cruising Buzzards Bay and the Islands last summer. He had served the Beverly Yacht Club as Fleet Captain and was active in the Mattapoisett Power Squadron. He is survived by his wife, Lillian, two sons, a daughter and a stepson. To his widow and family the class extends sympathy. . . . Just coming to our notice with no further information are reports of the following classmates who have died: **Webster Francis**, Rochester, N.Y., in May, 1974; **Henry Janson**, Danvers, Mass., July 4, 1977; **Arthur Bearse**, Columbus, Ohio, November 9, 1977. Your Secretary would like further information about these men from any source.

Since I will be out of the country for September I want to take this opportunity to remind you that I will be at home and anticipating your participation in the Class "Minireunion" here on Saturday, October 28. Mark your calendar now! — **Alice H. Kimball**, Secretary, P.O. Box 31, West Hartland, Conn. 06091

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John Lowe, III, is a senior partner, T.A.M.S. Engineers and Architects, New York, N.Y. John is also chairman of the U.S. committee on large dams and partner in charge of engineering for the world's largest dam, Tarbela Dam in Pakistan. He is scheduled to give the Honorary Nabor Carrillo Lecture of the Mexican Geotechnical Society in November, 1978. . . . **William E. Hartmann**, a partner of Skidmore, Owings and Merrill, participated in a symposium on urban planning in Cairo, designed to build a viable economy for Egypt. Skidmore, Owings and Merrill are designing a museum for the Egyptian government. . . . **Joe Heal** has recently retired and spends the winter in Florida, spring and fall in Hingham, and the summers in Maine. He and Marion have done some traveling in Europe and Joe took a trip down the Colorado River. Their son Josiah, Jr., is a pilot with North Central Airlines and has just recently become the proud father of a baby girl. Best wishes to Joe and Marion and to any other of our class who have retired. Drop a note to let your secretary know the details so that they can be included in the class notes. — **Robert H. Thorson**, Secretary, 506 Riverside Ave., Medford, Mass. 02155; **Lester Klashman**, Assistant Secretary, 198 Maple St., Malden, Mass. 02148

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Reunion 40 is over. Those of you who did not attend missed a great experience. Among other events was a cruise in Boston Harbor with a clambake on Georges Island. Fellow classmates who have spent their entire lives in Boston admitted that they had never seen or had the chance to appreciate Boston harbor from the water.

We have a new president — **Dave Wadleigh**, who served us so well in planning Reunion 40. **Don Severance** was elected Vice President. **Ed True**, as Treasurer, and your not-so-humble Secretary were not able to escape another term. The class gift, responding to the insistent urging of **Haskell Gordon** and **Norm Leventhall**, went far beyond my expectations — well over $600,000! **Ed Hadley**'s reunion book, "The Class of 1938 Revisited After 40 Years," is just super. Expurgated copies (without photographs) have been sent to all who paid class dues; the good copies were sent to subscribers who paid $5 each. If you want a copy, send five skins to Ed — he may have several copies.

Russell Coile wonders whether he has established a new class of '38 record for "Slowness in Studying." He received a Ph.D. in Information Science at The City University, London, England in May, 1978, two weeks before our 40th reunion. . . . **Harry J. Green, Jr.** reports that he is still ice skating with Genesee Figure Skating Club and hopes to visit Scandinavia this summer. . . . **Harold Rosenthal** writes that he is currently Assistant General Manager Atlantic Gelatin Division General Foods Corp., Woburn, Mass. . . . **Wilbur Rice** sold his business, Flomatic Corp., to a French manufacturing company. Although he is now Chairman of the Board of Trustees, he is not

very active in the affairs of the company. He is very busy with Bennington Museum and Bromley Ski Area. . . . **F. Robert Bergseth** recently retired as member of State of Washington Board of Engineering Examiners after 20 years service under two governors. . . . **A.P. Stergion** expressed his regrets on missing the Class Reunion, but hopes to make the 45th. . . . **Burt Grosselfinger** arrived home after the 40th Reunion to find his rhubarb crop ready for pulling. Fermentation is going along merrily and he expects there will be 100 properly aged bottles to bring to the 45th Reunion.

Your Secretary is sorry to report the passing of two members of the Class of '38 — **John R. Bennett** on June 8, 1977, and **Carl V. Moberg** on December 13, 1977. — **A. L. Bruneau, Jr.**, Secretary, Hurdman and Cranstoun, 140 Broadway, New York, N.Y. 10005

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Harold Pope, Chief Executive Officer of Sanders Associates, Inc., recently chaired the Fifth Annual Distinguished Citizen Award dinner to recognize the man making outstanding contributions to the economic and cultural betterment of New Hampshire. Harold has lived in New Hampshire these last 25 years or so. In 1976 he was honored with the M.I.T. Corporate Leadership Award. . . . **Wes Kuhrt**, vice president — technology for the United Technologies Corp., is pictured in a handsome color portrait in the company's annual report. . . . Prilla and **Gus Hunicke** enjoy sailing these days, sometimes on Long Island Sound, often during winters around the Virgin Islands and recently in San Diego. Gus built a business to manufacture and sell timing devices and is now due extra congratulations because some of his children have taken over its operation.

Virginia Barber writes from Quebec that she attended a convention in England and toured Europe afterward. . . . **Bill Bassett** retired from Bethlehem Steel Corp. and now enjoys part-time teaching in the Engineering-Science Department at Lafayette College. . . . Bille and **George Cremer** write from England that they expect to spend some months on the Continent and then return to the U.S.A. for the 40th Reunions of their classes at M.I.T. and Emerson College. . . . **John Dodge** retired from General Electric Corp. and divides his time now between consulting and boating.

Irv Peskoe continues to practice law and play tennis. His youngest daughter just received her law degree, and Irv reports that he hopes she will replace him at law, but not at tennis. . . . **Ruth Pitt** earned her Ph.D. in psychology at the University of California at San Diego during 1976. She is now an assistant professor at the University of Minnesota. Ruth writes: "Does this give **Eli Dannenberg** a run for his money as the record-holder for the longest interval between S.B. and Ph.D. degrees?" — **Hal Seykota**, Secretary, 1421 Calle Altura, La Jolla, Calif. 92037

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The Happening: **Edgar L. Bernard** writes, "I did not get the impression at the 35th that our classmates were particularly interested in returning to Cambridge." He suggests that with the regional division of the country used by the federal government, a lottery be conducted to select a region for the next reunion, excluding Region I, New England. At the 40th another lottery would be held for selection of one of the remaining eight regions for the 45th. "In this way each region or area would eventually have the honor and opportunity to be the host." Bernard's suggestion is certainly rooted in optimism. We shall have held our 80th Reunion on completing the round of the ten regions! Your feelings and suggestions for the 40th reunion are solicited.

What More Can We Say? **I. M. Pei** has fired the imagination of everyone who has seen the nation's new addition to the National Gallery of Art. *Newsweek*, May 22, says, "It is arguably the finest museum space — one of the finest public spaces, period — in this country."

Kudos: **David Brown**, Executive Vice President of Halcon International, has been elected to membership in the National Academy of Engineering for his "contributions to petro-chemical processing technology, engineering literature, and engineering education." Brown, who holds 20 U.S. patents and hundreds of foreign patents, has guided research and development operations at Halcon since 1952. The Academy also announced the election of **W. Kenneth Davis**, Vice President of Bechtel Power Corp., as its vice president for a four-year term.

His Favorite Theme: **J. Herbert Hollomon**, Director of the Center for Policy Alternatives at M.I.T., was a major participant last October in the National Symposium on Technology and Society held at Villa Maria College in Erie, Penn. By the way, Hollomon is a founding member of the National Academy of Engineering.

M.I.T. Fund Notes: **Millard F. Dowell** is active in local chapters of A.S.M.E. and the Erie Engineering Society Council. . . . **Lester Lees**, Professing at CalTech, has been active recently with a group from the Jet Propulsion Lab on the problem of high-level radioactive waste disposal. He is also working on long-range environmental impacts of energy policies. . . . **W. C. Steber** continues at the helm of W. C. Steber Associates, consultants to industry and government in matters related to transportation, energy and defense.

Political Data: **M. Arnold Wight, Jr.**, a New Hampshire representative from Amherst, has been appointed to that state's Commission of Central Data Processing. Wight is a member of the New Hampshire House Science and Technology Committee.

R.I.P.: **John K. Ross** of Montreal, Canada, died. He is survived by his wife, Helen, who is also a '40 classmate. . . . **George C. Halstead** died in April while on a business trip to London. He joined Alcoa Steamship Co. after his separation in 1945 from active duty with the U.S. Navy, and became the company's president in 1963. He had just agreed to serve as a member of the M.I.T. Department of Ocean Engineering's Visiting Committee. — **Frank A. Yett**, Secretary, P.O. Box 562, Long Beach, Wash. 98631

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Science Award: **George Power**, Director of Research for the Formica Division of American Cyanamid Co., was the recipient of the company's scientific award which is given to research scientists for outstanding achievement, creativity, and ingenuity in the discovery and development of new products and processes.

First Annual Engineering Leadership Assembly: **Rogers Finch**, Executive Director of A.S.M.E., presented the technical goals for the engineering profession.

National Academy of Engineering: Our classmates **Courtland Perkins**, President of the Academy, announced newly elected members — **John Steiner**, for leadership in the design of the Boeing 707, 727, 737, and 747, and **Ken Roe**, for leadership in design efforts for the application of new fields of technology in power generation.

Beaver Tales: **Don Dixon** in Florida exports heavy construction equipment to Latin America, especially caterpillar equipment. . . . **Charles J. Muller** has been practicing architecture for 32 years in Commerce, Tex., specializing in schools and banks. . . . **Bill Kussmaul** visited me in Pittsburgh and is Sales Manager of the Dyna-Mist Chemical Co. and lives in Philadelphia. . . . **Edith Corliss**, who wrote a National Bureau of Standards handbook on research in hearing and speech communication, writes of her progress: "An example of progressive complexity of bureaucratic organization. In *same job* I have progressed from Div. 4 to Div. 6 to Div. 201 to Div. 200 to Div. 204 to Div. 735!!"

It's only the Fourth of July, but I must wish you a happy Labor Day as this is the August/September Issue. Keep writing so I can keep writing! — **Henry Avery**, Secretary, U.S.S. Chemicals, 2863 — 600 Grant St., Pittsburgh, Penn. 15230

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Really big news this month is the election of **Paul Hotte** as a member of the M.I.T. Corporation. Fairly big news this month is the re-election of **Ed Vetter** to a new term on the Corporation. Not so very big news this month is that your secretary has been appointed chairman of the 1979 Technology Day committee. With Hotte, Vetter, and also **Dick Meyer** now serving on the Corporation, our class should have things pretty well in hand.

A very interesting letter from **Donn Barber** tells that he is now Business Analysis Manager of Du Pont's Plastics Products and Resins Department. Donn has also been elected District Governor of the Lyons International District 14-P, covering about 3,000 Lyons in 67 clubs in the eastern Pennsylvania area. . . . **Alan MacNee** has a very interesting observation from his vantage point at Ann Arbor — he writes, "Each year the freshpersons look younger, but trying to teach them the wonders of circuit analysis and design is still good fun most of the time!" . . . **Chris Peek** continues in new product development at G.T.E. Currently Chris is working out of the Waltham laboratories, and his group is concentrating on energy-related electronic products. . . . **Al Hayes** has moved the main office of his consulting engineering practice to Orange, Calif., and he is spending a lot of time flying the company airplane between there, the original operating base in San Francisco and the location of a new office in the Phoenix/Tucson area. . . . **Robert King** has been appointed President of Union Carbide's recently formed Medical Products Division. Bob received his B.S. in chemical engineering at the University of Denver and got his master's degree with our class. . . . **Dan Schaeffer** has passed the examination for admission to the New York State Bar after working for many years as a registered patent agent. I do believe that his route to admission to the Bar by way of working as a registered patent agent is unique, probably not only for our class but for most all lawyers. Our very best wishes to Dan in his new career.

Charlie Speas (Mr. M.I.T. of Baltimore) has been appointed chairman of the International Relations Committee of the Society of Plastics Engineers. The committee maintains technical liaison between S.P.E. Chapters here and those overseas. Charlie and Betty are looking forward to considerable travel in Europe and other parts of the globe in this new assignment. . . . **Lou Rosenblum** shares a very interesting letter from **Ron Shanin** with us. Ron just returned to his home in Huntsville, Tex., after a seven-month lecture tour. Some of you probably remember that he showed his film, *Rivers of Fire and Ice*, at our 25th Reunion. That picture was later released commercially by Universal Pictures under the title, *African Safari*. Since then, Ron spent from 1970 until 1974 in central Africa and made a trip to Borneo and Thailand in 1976. He casually mentions that an African rock python bit his right hand and left four of his (the python's) teeth in one of his fingers. Equally casually, Ron mentioned that in 1972 he was blinded 14 hours by the venom of a black-necked spitting cobra, and in 1973 he was tossed on the horns of a Cape buffalo, losing three front teeth and injuring his back. I wonder why Ron didn't stay in the aeronautical engineering business!

Still in the vein of far away places, **Carl Jealous** completed construction and commissioning of a vanadium ore milling and roasting plant in Transvaal, South Africa, in 1977. While there, Mamie and Carl lived in Johannesburg but kept their home in Youngstown, N.Y. Carl is now back at the old stand as project manager for Union Carbide's Metals Division Engineering Group. . . . Congratulations to **Charlie Prohaska** who retired from Du Pont on July 1. His new home address is R.D. No. 1, Dingsman's Ferry, Penn., 18328, so anyone working his way through that part of Pennsylvania can stop in.

Our class president, **George Schwartz**, will have some very interesting announcements to make about planning for our 40th anniversary class gift very soon. I do hope to be able to run this news in

the next issue. Best wishes for a happy and healthy summer. — **Ken Rosett**, Secretary, 191 Albemarle Rd., White Plains, N.Y. 10605

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The 35th Reunion was a grand affair, and a good time was had by all. **Bill Laird** flew in from the east coast of Africa, where he had been at sea on a special teaching assignment. The hats this time were adjustable. Class officers were elected.

Charles Chubb writes that his former company, Dynell Electronics, was acquired by United Technologies and is now part of Norton Systems, Inc., where he is vice president for technology. . . . We regret to report the passing on of classmates **Wendell P. Turner**, **Basil Rabnett** and **Peter W. Forsbergh, Jr.**. . . . **Iz Lenzner** won the Governor's Cup at Brae Burn Country Club in Purchase, N.Y. — playing golf, that is. — **Richard M. Feingold**, Secretary pro tem, 779 Prospect Ave., West Hartford, Conn. 06104

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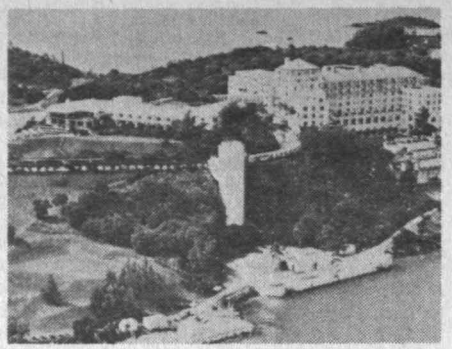
Starting with a dinner meeting at the M.I.T. Faculty Club last December, and continuing with coffee meetings at the homes of Edna and **Stan Warshaw**, Marguerite and **Ed Ahlberg**, and Anita and **Les Brindis**, a group was formed to plan our 35th reunion. The 34th reunion was held at the Tides Inn in Virginia in the hopes that it would attract classmates from outside the New England area and solicit their ideas and suggestions for 1979. Needless to say we had a fine time and were reacquainted with Virginia hospitality. We could use up the whole class notes to say what happened. We won't. But here's a hummingbird's view.

Ruth Sebell's clever remarks on many subjects; the yellow rain slickers of Priscilla and **Bob Breck**; Carey Nelson's private showings of jewelry designed and made by her; Buz and **John Hull**'s 2 a.m. arrival at the Inn; helpful hints from travel agents Carmen Van Ravenswaay and Dorothy Lawton; **Norm Sebell**'s persuasive leadership; the bedraggled look of **Melissa** and **Newton Teixeira** and Doris Woodworth returning from a tour of Williamsburg in the rain; Margery Whiffen's reminiscences of an Hawaiian childhood; **Bill Van Ravenswaay**'s turtle neck shirts; **Ken Nelson**'s business acumen; Edna Warshaw's shopping guidelines; **Chet Woodworth**'s rosy cheeks; **Andy Corry**'s dance floor heroics; **Dick Whiffen**'s height; the appointment of **Chuck Van Ravenswaay** as the official photographer; **Hank Lawton**'s trick knee, curable only by dancing; **Stan Warshaw** learning to use his new camera.

Some business was conducted; after all, the purpose of the 34th was to launch the 35th. To provide other locales with a nucleus of good feeling, the like of which we've enjoyed around the home base of M.I.T., we asked for and won volunteers. They will act as focal points, message centers, etc. on Class Reunion 35 matters. They are **William T. Van Ravenswaay**, 61 Garden Road, W. Larchmont, N.Y. 10538, (914) 834-2748; and **Henry D. Lawton, Jr.**, 123 Hatton Drive, Severna Park, Md. 21146, (301) 647-1616 or 544-1317. Send a card or call the nearer of these satellite centers. Even if you don't go to Bermuda, you'll have a good time meeting classmates at these mini-reunions. If either of these locations is inconvenient for you, we'd like you to volunteer to act as focal point in your area; Chicago, Cleveland, St. Louis, Detroit, among others, need local class leadership, says **Norm Sebell**. In June Ruth and Norm Sebell called a dinner meeting to confirm reunion plans. The plans for the 35th accommodate Technology Day which is June 8, 1979. Those who wish to attend Tech Nite at the Pops on Thursday, June 7, the pre-Pops buffet, and the Tech Day program can, if desired, receive free housing on campus (we're a reunion class).

Our flight to Bermuda will leave between 9 and 10 a.m. on Saturday, June 9. You can be on the pink sand by noon. We will be staying at Castle Harbour Hotel, Beach, and Golf Club, one of those classic hotels that shows up in the Bermuda



Here's where we'll have our XXXVth!

posters. Although costs are, of course, subject to air fare variations, it appears that we can fly in on Saturday and fly out on Wednesday — four nights for about $395 per person (double occupancy), full breakfast and gourmet dinner daily, all gratuities and taxes paid, round trip between airport and hotel, and welcoming rum swizzle.

Norm is reunion chairman and would like to know if you are going to Bermuda, are willing to contact classmates in your area, and, if the Institute has your most recent address. Contact **Norman Sebell**, 100 Burlington Street, Lexington, Mass. 02173, (617) 862-2935.

Providing another mini-reunion, there will be a "Dutch treat" dinner meeting, drinks at 6 and dinner at 7, at the M.I.T. Faculty Club, Saturday, October 14, 1978, for members of the committee, class officers, those who volunteered to publicize the Bermuda reunion in their area, and all other interested classmates. At this meeting Norm will bring us up to date on the details of our trip, etc. (Please notify **Melissa Teixeira** by October 9 if you are coming and how many of you.)

We do have other news. In the May issue of *Diesel and Gas Turbine Progress* there was an article by **Walter Masnick**, the President of Flo-Tron, Inc., Patterson, N.J. . . . From **Bill Sadler** we have a flap-fact that he had seen two former class officers, **Paul Robinson** and **John Barmby**, at a meeting of the Washington M.I.T. Club. . . . Responding to our plea in a previous issue, Stan Berinsky who started out with our class but who chose the class of '48 (the year he graduated), sent us a write-up of his career to date. Stan is still with Lockheed where he's been for 26 years since his old outfit (Stavid) became Lockheed Electronics. Stan and Ruth have been on the West Coast for almost a dozen years now. They "enjoy the blessings of reasonably good health, a devoted son and daughter-in-law, and some wonderful friends." We are pleased to hear that they are well and hereby invite them (and any other "charter" or "associate" members of '44) to join us in Bermuda.

Two prestigious appointments have been announced: from Beverly, Mass., in March, **Lillian Kasparian Derderian** was appointed Dean of Students at the North Shore Community College; and in Wilmington, Del., **Robert J. Reilly** was appointed to the new position of Vice President of Finance for ICI Americas, Inc. Bob received his M.B.A. from the University of Pennsylvania after having properly launched his educational career with a B.S. in Course X at M.I.T.

The Institute has informed us that **Marshall R. Ross** died March 23, 1976.

This year, Technology Day (remember when it was Alumni Day?) was on Friday, June 9. Again the program held in Kresge Auditorium was excellent. **Bob Clarke** came north from New Jersey to attend the E.E. departmental reunion on Thursday and the activities of Technology Day along with your secretaries. We were pleased to see **John Cooper** at the luncheon. At the evening reception were also our classmates **Andy Corry**, **Jack Frailey**, and **Bob Horn**, as well as old friends of the class, Stan Proctor and Kemp Maples.

As '44s who married each other, your Secretaries would like to hear from another '44 couple, **Rosemary** and **Bob Bartz**.

We hope your summer was pleasant and the fall finds you making plans to attend the 35th Reunion in Bermuda. — **Melissa** and **Newton Teixeira**, Co-Secretaries, 92 Webster Park, West Newton, Mass. 02165

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John Karmazin (Vice President in Charge of the Entire Midwest) came to town June 1 for a micro-reunion of the Class of 1947 (early, before the rush of Technology Day). Through the efforts of **Dick Knight** and his secretary, a motley crew was assembled, made more mottled (mottlied?) by the absence of **Claude Brenner**, who cleverly contrived a previous engagement. Present at dinner with John were Dick Knight and Joan, who have recently moved from their harborside apartment to a remarkable condominium in a lovely old building in Brookline; **Bob Hagopian**, now fairly well settled in his new job as Director of Corporate Relations at M.I.T., **Ginny Grammer**, whose name appears regularly in this column, and former Karmazin roommate **Don Van Greenby** and guest Kathy. Don seems to have a reputation for driving around (that is to say, circling) the North End looking for non-existent restaurants.

John reports on the meeting: "To bring everyone up-to-date, I would like to mention that we finally found (and ate dinner at) Veronique's. At our last Board of Directors meeting I received approval for KPC (Karmazin Products Corporation) to join the M.I.T. Associates Program. Our Vice President of Research, Ivan Woodhull, will be making our first visit under this program on June 27 and 28. One more thing — one reason we joined this program was that **Bob Hagopian** and Dick (both) said, 'Join! or stay out of our territory.' . . ."

Karmazin builds coolers of many kinds which are used in equipment of all dimensions, from automobiles to gigantic earthmovers. I do have one question, though, John. What size are your "aftercoolers" — quarts, liters, or fifths?

John was also investigating solar energy applications while he was here. Karmazin Products has taken heat away for so long, I guess he figures it's time to give some back. Although he planned to look at the (passive) solar house while he was here, his interest is really in active systems — what else for a guy who orders dinner long distance and show up with corsages for all the ladies?

Technology Day brought out a number of locals: prize for the greatest distance traveled might go to **Don vanGreenby** and guest Kathy, of Lowell, unless you want to count Other Residences of people like Brooklineites **Jack Rizika** and Karen (house in England) and **Dick Knight** and Joan (New Hampshire). Attendees included Mary and **Claude Brenner**, **Bob Hagopian**, **Marty Haas**, **Bob Danner**, **Ginny Grammer**, Lois and **Harl Aldrich**, Jane and **Jim Phillips**, and **Bill Page**, who is in Planning at Polaroid. We witnessed the admission of a new member to the class: at the Luncheon, **Doug Carmichael**, of Ocean Engineering at M.I.T., was declared an Honorary Member by Jack Rizika. If a formal vote is required, it will be taken at the 35th Reunion. Meanwhile, Doug may enjoy all privileges (and responsibilities) of our new affiliation.

Several others were listed as planning to be there, but were not in evidence at the events I attended. You know who you are: we missed you.

More honors for our class at the Institute: **Harl Aldrich** is the new Vice President of the Alumni Association. Thus the Class of '47 ties up two of the important spots in the Association. **Dick Knight**, as you know, is Secretary.

Claude Brenner continues to discuss the present state of solar energy technology before groups throughout the Northeast. He is Program Director at the Northeast Solar Energy Center, Cambridge, which serves New England, New York, New Jersey, and Pennsylvania. The Center is initiating programs to accelerate the commercialization and widespread use of solar energy in the Northeast.

Vince McKusick, Chief Justice of the Maine Supreme Judicial Court, was the speaker at the Maine State Bar Association's annual meeting this year.

Vernon Sholund is currently a consulting mathematician at the Jet Propulsion Laboratory, Pasadena, Calif., working on lasers in the Theoretical Physics and Cosmology Group of the Physics Section, Earth and Space Sciences Division. He writes: "In the camp of the enemy! (J.P.L. is a branch of CalTech, funded by N.A.S.A.) Am preparing bequest to support prizes for math papers for authors under 9 (first critical point) and 15 (second critical point) and scholarships in Logic and Foundations of Math. Someday will explain why 9 and 15 are critical points in a mathematical career." Take care of yourself, Vern; we would rather hear about it from you.

Another Flash! release in March, received in July for publication in August: **G. Robert Keepin**, Director of the Nuclear Safeguards Program at the Los Alamos Scientific Laboratory, was appointed General Chairman of the 19th annual meeting of the Institute of Nuclear Materials Management held June 27-29 in Cincinatti, Ohio. I.N.M.M. is an organization of some 560 professionals around the world working in governmental, industrial, and academic institutions where nuclear materials are used in research, development, and production activities. Nuclear material managers develop and establish program standards, technical capabilities, and requirements for plant-wide nuclear materials accountability and control systems and associated plant protection systems.

The first Oscar to be received by a classmate was won this year by **William Latady**, president-founder of Latady Instruments, Hingham, Mass., for the invention (with N. Paul Kenworthy) of the Kenworthy snorkel camera system, a motorized, floating camera with a long, optical relay tube and split vision lens. The arrangement permits the cameraman, operating up to 50 feet away, to see what he's shooting with closed-circuit television. Bill has designed, developed, and manufactured instruments for used in many scientific fields, including oceanography, seismology, geology, and medicine. Current emphasis is on optical and mechanical instruments for the U.S. government. Other landmarks in Bill's life include a mountain range and an island at the South Pole, named Latady in his honor by the U.S. and British governments after a 1947-48 expedition for which he was the director of photographic and photogrammetric operations. In 18 months their party of 23 explored 250,000 square miles for the first time, made 14,000 trimetrogen aerial photographs of a known but unmapped additional 450,000 square miles (almost as big as Mexico), with ground-control points for accurate correlation. Bill recently hosted a reunion of some of the expedition members.

I am sorry to have to report that **Russell Palmiter** died in January. He was an Air Force pilot with the rank of Major in World War II. He had lived in Cohasset for 30 years, and leaves his wife, Elsa (Brash), a son, Lee, and two daughters, Lynn and Lesley.

Dolly and **Al Steinmayer** are still living in Berwyn, near Philadelphia, and daughter Janet, whom we reported out of Bryn Mawr, has been admitted to the University of Chicago Law School. (Yes, Al, there is a Virginia, and she gets those little notes you write on the flaps of the $$ envelopes.)

I must have uncrossed my fingers without realizing it: **John Ebersberger** was planning to come to town, but I didn't see him. His note: "After a long cold winter and a drenchingly wet spring, it will be a relief to see many of you on Alumni Day. Hopefully better weather than last year. Keep your fingers crossed."

Jim Phillips checks in: (Thanks, Jane) Jim is Manager of the Retirement Benefit Plans Division of Tucker, Anthony, and R. L. Day, Brokers, and lives with wife Jane in Manchester, Mass. Since graduation he has been with M.I.T. as Assistant Dean of Students, with John Hancock in Sales for their Group Insurance Department; and was Vice President of Vance Sanders, Investment Management Organization. His interest in health care is reflected in his work as a hospital trustee. He is also an S.I.A. Governor. Son James, Jr. works in Executive Recruitment with Russell Reynolds and Co., New York; son Scott is an architect; son Christopher is a broker with Spaulding and Slye, Industrial Real Estate.

Love to you all. — **Ginny Grammer**, Secretary, 62 Sullivan St., Charlestown, Mass. 02129

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George Clifford, chairman of our 30th Reunion, assured a winning reunion by arranging perfect weather for the weekend at Chatham Bars Inn. **Don Noble**'s program was thoroughly enjoyed by our class, and our program was complimented by another M.I.T. class that shared the Inn with us. Gloria Monosson and Nancy Noble did their thing as hospitality committee on the bus from Cambridge to Chatham and everyone rolled off the bus in a delightful humor. **Leon LaFreniere** tested the clams for our clambake to assure their purity, and the rest of us tested their flavor which was excellent.

Sonny Monosson produced our yearbook on time — in very little time — and everyone enjoyed reading the latest happenings in classmates' lives. **Graham Sterling**, our treasurer, kept us in the black.

Bob Mott was master of ceremonies on Saturday evening. He awarded prizes, judged contests and provided the delightful wit we remember from undergraduate days with Bob. **Milton Slade** compiled a questionnaire and awarded prizes for giving up smoking (5,000 times) to **John Kirkpatrick**, travelling the farthest to **Bill Zimmerman**, and losing the most weight since graduation (15 pounds) to **Norm Seltzer**. Martha and **Bill Katz** judged the jitterbug contest and had difficulty in selecting the winners from a talented field of 12 couples. With the help of the band, they decided on two winning couples — Paula and **Irv Kagan** and Nancy and **Don Noble**.

Harry Ottobrini ran the golf tournament and presented the awards. Harry also arranged a boat trip on Saturday afternoon which was probably the most popular single event besides eating — the great food arranged by **Leon LaFraniere. Ken Brock** conducted a well organized tennis tournament that produced more winners than there were prizes.

Saturday evening we danced to a five piece orchestra — three from Chatham with **Bill Katz** on piano and **John Kirkpatrick** on trombone. Both Bill and John soloed during many numbers that the orchestra played. **Norm Seltzer** conducted a contest for the most unique memorabilia displayed at the dance and related to the year 1948. **Bob Mott** as master of ceremonies examined, described and critiqued the memorabilia.

Reunion attendance included 78 classmates and their wives, friends and children. In total over 150 people attended part or all of the reunion. At the committee's final meeting after the reunion to summarize the 30th, we all felt that the reunion was a success.

Gil Rohleder has been named Senior Vice President of MAPCO, Inc. in Tulsa, Okla. Gil will be responsible for operations of the company's Mid-America Pipeline System. Gil has been with MAPCO since 1960. Gil's company operates the largest liquified petroleum (LPG) common carrier pipeline system in the U.S. . . . **Bernie Gordon** was the keynote speaker at Electro '78, an electronics industry meeting in Boston. Bernie addressed the problem of educating and training the new engineers required to maintain America's prime position in electronic technology. He emphasized the need to provide quality — not quantity — resourceful, broadly educated and experienced project engineers capable of conceiving and carrying out new developments and of properly supervising less experienced subordinates.

Some of the factors that can reduce the quality of an engineer's training are reduced standards in college curricula, trends towards specialization, overemphasis on computer sciences, government procurement policies and practices, and management laxity in providing and requiring proper industrial training, apprentice programs and incentives. Bernie recommended that programs be established to attract young people of superior intellect and will to engineering curricula based on core courses and written and verbal communications together with appropriate leadership orientation courses. These must be supplemented by programs of engineering apprenticeships. Managements will have to seek engineering excellence and reward those responsible for achieving innovative success. Bernie is Chairman of the Board at Analogic, a director of the Innovation Center at M.I.T., and a member of the Massachusetts High Technology Council. Analogic's earnings in the first six months of 1978 were double those of the previous year. Sales for the 1978 period were $12.4 million or a 75 per cent increase over the previous year.

Bernie Gordon '48

Bud Garforth opened his third Gingiss Formal Wear Center in Jackson, Miss. He's having fun after 25 years in heavy industry. . . . **Bob Chandler** completed 25 years of service with Diversey Corp. in 1977. Since 1968 he has been technical vice president. In 1977 Bob joined the grandparents' "brigade" when his grandson Jeremy Scott Mayer was born in Racine, Wis. . . . **Reginald Stoops** joined Proform, Inc., as Director of Corporate Planning and Development, after consulting with them. They specialize in large structural reinforced plastic parts such as barge covers, tanks and domes. . . . **Arthur White** is Quality Assurance Manager in Ireland for Atlantic Richfield's Medical Products Group.

Jack Lake reports that he is rehabilitating railroads in New York. His son Anthony graduated from Course VI (Computer Science) in 1976. When his other two children finish college, he is going to take a long train ride! . . . Polly and **Nick Caldwell**'s daughter was married in June. A few days later Nick went into Salem Hospital for a hip replacement operation. Nick said there were over 200,000 similar operations last year. Sorry you missed the reunion, Nick, and we wish you a speedy recovery. . . . Jean and **Jim Connors** were at our 30th Reunion. Jean had a hip operation several months ago. Jean was dancing and climbing from a speedboat to a sandbar at Chatham. Her operation was an obvious success.

John Kirkpatrick is at the Institute for Gas Technology in Chicago. The Institute provides consulting and research for the energy industy. . . . **Fred Firestone** will be on sabbatical from Illinois State University for the coming year. Fred is Professor of Economics. He will be at Yale Law School as a candidate for the master of the study of law. Yale's program is for faculty teaching social sciences at the university level; five persons are accepted each year for the program. Fred's wife Lois, eighth-grade daughter Julie, and sixth-grade son David will be with him in New Haven. . . . I called **Roy Evans** recently. He is manufacturing lamps in Wakefield, Mass. He and his son attended the alumni seminars offered on campus during the semester by M.I.T. — **S. Martin Billett**, Secretary, 16 Greenwood Ave., Barrington, R.I. 02806

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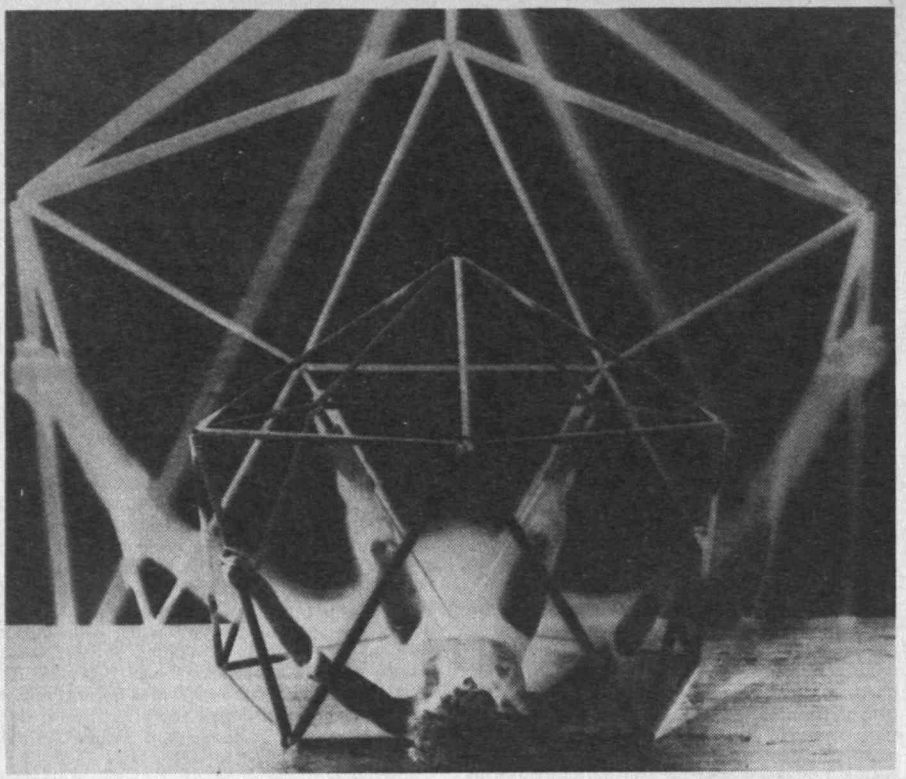
James M. Lydon of Wayland, Mass., has been named Senior Vice President of Boston Edison Co. where his job will be to oversee the power



Interlocking pentagrams are the basis for this skeletal version of The Icosahedron *shape which its creator, Joseph Hodnick, '51, claims can focus the energies of a person meditating within.*

Star-Angled Meditation

"Find a church with violet-colored light," recommended Leonardo da Vinci to the seeker of calm meditation. This idea that structure and color affect one's state of mind was the impetus for artist Joseph Hodnick, '51, to design a participative sculpture, *The Icosahedron*, on exhibit at the Boston Visual Artists Union Gallery last spring.

I crawled inside the canvas-covered frame (its shape and title derive from the fifth Euclidean solid of interlocking pentagrams) and sat yogi-style. Images of myself mutiplied upon the reflecting inner surface. I felt lifted beyond its five-pointed horizon, contained by the central capping peak. From a control switch I chose among seven colors, and tiny lights altered the ambience from soothing green to kinetic red.

When I emerged Mr. Hodnick explained his work: "I chose the shape for both its inward and social aspects. The crowning point of the meditation space draws energy upward, while the star-like horizon draws outward, toward people." Its heritage comes from the Pythagorean brotherhood, who believed that geometry was sacred. They felt it represented philosophy and reality in pure form, and that the pentagram (or star) was the most social of the geometric forms.

The Icosahedron is a synthesis of East and West, scientific and mystical. The colors correspond to the seven healing rays which affect the Chakras, or the body's energy points, recorded in ancient Indian scriptures. Da Vinci's violet, for instance, finds its corresponding Chakra in the crown of the head, signifying the highest meditative state.

Bathing in these colors has a restorative influence, believes Mr. Hodnick, who finds scientific confirmation of these ideas in the work of psychologist Faber Birren, *Color Psychology and Color Therapy*.

The Icosahedron has not reached its last embodiment. Still flirting with other ideas for its use, Mr. Hodnick imagines incorporating this use of color in biofeedback systems and in group-decisionmaking processes. Meeting participants could each have a reaction button by which attitudes can be expressed in colors of consensus rather than individually. But for now, he hopes to find people who relish the idea of their own private sanctum. — *S.F.*

Jon Ganger '50

supply administration, commercial and corporate relations organizations, and rate research and forecasting. He was formerly Vice President for Corporate Relations. Jim has finished the Harvard Business School Program for Management Development and the General Electric Graduate Power System Engineering Course in Schenectady, N.Y. He is President and a Director of the Executives Club of the Greater Boston Chamber of Commerce and a Director of the Colonel Daniel Marr Boys' Club, Dorchester, Mass., and he's active in other civic and business organizations.

Jon L. Ganger, who lives in Lexington, Mass., has been elected a Director of Frank B. Hall and Co. of Massachusetts, Inc., Boston. The firm is New England regional headquarters of Frank B. Hall and Co., Inc., international insurance brokers. Jon joined the organization in 1966 as an account executive, was made Vice President in 1971 and Senior Vice President in 1977; he is a licensed adviser and broker, a member of the National and Massachusetts Societies of Professional Engineers.

Allen Bryson gives us the following report on his four daughters: Judy, graduated from Wheaton College (Ill.) with honors in May, 1977, is now employed with Ralph M. Parsons Co. in Pasadena, Calif. Janet, a National Merit Scholar, is now a freshman at Wheaton; Lesley and Laurel continue in the Arcadia, Calif., schools.

David E. Webster and his wife, Carole, have moved to Nantucket after Dave retired as President of Dynaco, Inc., in the spring of 1977. They are now in the process of restoring an 1827 house on Main Street. Dave's book, *To Love and To Cherish*, has broken the 300,000 - mark in sales. He is trying to maintain his backgammon game while serving as the President and Treasurer of Heard-Webster Associates, Inc., a Nantucket company that specializes in real estate, insurance, and financial consulting. His son, Chip, plans to attend M.I.T. this fall.

N.A.S.A. has announced that **John F. McCarthy, Jr.**, Director of M.I.T.'s Center for Space Research, is to become Director of the Lewis Research Center in Cleveland, Ohio, on October 1. He will take a leave of absence from M.I.T., where he has been Professor of Aeronautics and Astronautics since 1971 and Director of the Space Research Center since 1974. Dr. McCarthy is widely recognized as an expert in systems engineering and vehicle design; in 1973 he was awarded the Meritorious Civilian Service Award by the Air Force for his work on the C-5A transport plane.

Corning Glass Works of Corning, N.Y., has announced the appointment of **Thomas Howitt Jr.**, as Corporate Director of Energy and Environmental Control, Manufacturing and Engineering Division. Tom joined Corning in 1950 and since 1975 has been Manager of Manufacturing in the Science Products Division. . . . **A. John Esserian** is now Director of Industrial Relations responsible for all employee programs, including recruitment, development, human resources, and benefits. Most recently he was Director of Industrial Relations at Baird Atomic, and before that held senior personnel management positions with G.C.A. Corp. and Epsco, Inc. John resides in Cohasset. . . . **James J. Broderick** is currently president of Micro Chemical Industries in Memphis, Tenn., whose business is the production of steam and a low-cost replacement for carbon black by the

combustion of rice hulls.

Lawrence Gould, formerly President of Microwave Associates, Inc., is now Chairman of the Board, President, and Chief Executive Officer of M/A-COM, Inc., the corporate successor to Microwave. Microwave will continue as a separate operating activity of M/A-COM, Inc., producing microwave components and equipment under its own trade name and trademark. Larry has been with Microwave since 1953, its President since 1969, and its Chief Executive Officer since 1975. He is a resident of Brookline, Mass. — **John T. McKenna, Jr.**, Secretary, 2 Francis Kelley Rd., Bedford, Mass. 01730

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There is a very interesting editorial by our own **H. H. Woodson** in *Power Engineering Society* magazine. Mr. Woodson is President of the Society, which is part of I.E.E.E. It's good to hear another member of our class has made it to the top of a major engineering society. . . . **G.W. Meckert, Jr.** is Director of Systems Development for Thermonetics. For those of you who do not follow the world of energy supply, the Thermonetics sign reads, "Caloritic Recovery Anaerobic Process, Inc." — C.R.A.P., for short. This is the first plant producing quality methane gas from cattle manure.

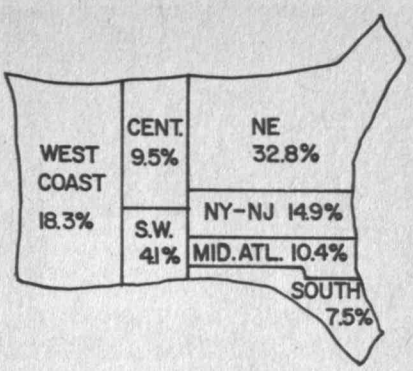
The new Alaska State Capitol is the handiwork of **Henrik Bull**, principal in the firm of Bull, Field, Volkmann and Stockwell. The winning design submitted by this group received comments such as, "It is almost a stroke of genuis in terms of design." This group also created the internationally acclaimed film, *Cities for People*. We could sure use them here in Los Angeles. . . . A note from **I. Victor Yancey** states he is still working for the U.S. Air Force at Aeronautical Systems Division, Wright-Patterson. Victor is also President of the board of trustees for Jefferson Regional Water Authority who are in the process of installing a complete rural water system. . . . **Myron Lecar** has taken a year's sabbatical to study at Hebrew University and Tel Aviv University in Israel and Churchill College, Cambridge University in England. Jolly good year, Myron.

I was saddened to hear of the passing of our classmate, **Peter Wieboldt Steck**, in Winnetka, Ill. Peter died of a stroke. He was the grandson of the late William Wieboldt, department store founder. Peter was a volunteer tutor in Winnetka public schools and did volunteer work recording for the blind. He was a Korean war veteran and had taught at Brown University, Providence, R.I.

Another classmate, Dr. **W. Gerald Austen**, was elected president of the American Heart Association. Dr. Austen is chief of the surgical services of Mass. General Hospital and is Edward D. Churchill Professor of Surgery at Harvard Medical School. Having recently started a jogging routine, I can appreciate the good work of Dr. Austen. . . . A nice card from **Richard C. Reedy**, who recently moved the family to Gloucester, Mass., tells us their daughter Cindy is a full-fledged M.I.T. student, Class of 1980. Good luck to you, Richard and Cindy. . . . Your secretary recently took a trip to England — a great place when the sun shines, which wasn't too often. I'll be glad when they switch driving sides — almost demolished the car and my wife Shirley.

A letter from my M.I.T. roommate **Howard Levingston** stated that **William A. Krivsky** was awarded the Francis J. Clamer Medal by The Franklin Institute of Philadelphia for his 1954 invention of the argon-oxygen-decarburization (AOD) process which revolutionized stainless steel making. Our kudos to Mr. Krivsky for this outstanding honor. Will this bring down the cost of our good tableware? For some local news, I bumped into **Ted Porush** at a friend's barbecue. He has relocated from Monterey Park to Woodland Hills in the San Fernando Valley and has taken a new position with Robert Clements and Associates. I also heard about **Jerry Title** who is with Pascoe Steel in Pomona. Jerry has been traveling very extensively for his company, including several trips to Nigeria. We all hope to get

Quarter Century Quiz



Twenty-five years after graduating, the typical M.I.T. alumnus earns between $35,000 and $50,000, has a net worth of between $100,000 and $200,000, and feels he is "right on schedule" or "doing better than expected" in his work and life.

In a nutshell, that's the picture painted by Martin Wohl, '53, Secretary of the Class, at the 25th Reunion last June. Classmates were asked by questionnaire about M.I.T., their professional careers, home and family, and various personal preferences. Based on a 31 per cent response, here's the full picture.

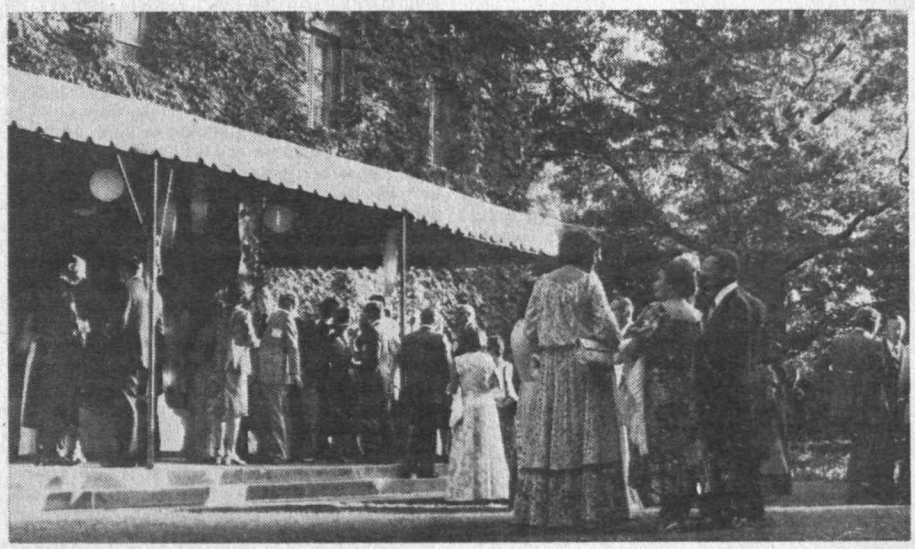
A large proportion (33 per cent) of '53ers still live in the Northeast. More than 90 per cent continued their educations beyond the undergraduate degree, either in pursuit of an additional degree (40 per cent for the master's) or occasional courses. And when asked, "Did you change fields after the S.B.?" 69 per cent said no.

In terms of occupation, the fields of management (34 per cent) and research and development (22 per cent) claim the majority; one quarter own their own businesses. *Changed employers* and *out of town moves* appear to be directly related, with the mean number of moves being four (maximum 30!). Sixty-seven per cent changed employers from one to three times.

Reporting 1977 income, 94 per cent claimed $25,000 to $75,000 (or above), which compares with 45 per cent nationally for white college graduates. Interestingly enough, virtually no correlation was detected between income and M.I.T. cumulative grade rating or income and graduate study. *If I could do it over?* Eighty-nine per cent would go back to Tech and 70 per cent would encourage their children to follow suit.

To move into the home scene, 75 per cent married while at Tech or within five years thereafter, and 58 per cent report *super* marriages, 36 per cent *good* and only six percent *not so good*. There are less in the *single* category than the national average (2.1 versus 5.6) and more *married once* (86.7 versus 79.6). In response to "How do you feel about a working wife?" 39 per cent said they *like the idea*, eight per cent *never!*, 27 per cent *part-time is o.k.* and 25 per cent *don't care*.

A typical '53er lives in suburbia, excercises regularly, drinks occasionally, doesn't smoke and spends his spare time working overtime (seven hours per week), reading (five hours), watching television (four hours), involved in group activities (three and one-half hours), and hobbies (five hours). Eighteen per cent own vacation homes, 26 per cent boats, and four per cent planes. Sixty per cent go to church rarely, but when asked, "What about sinning?" 75 per cent said no. Does that mean — no, it ain't what it used to be? — *S.K.*



As the map above shows, many of the Class of 1953 live close enough to return to M.I.T. on special occasions such as this reception at President Wiesner's house during the Class' 25th reunion in June.

That's a big check being proudly waved by President Jerome B. Wiesner at the Technology Day Luncheon: $244,000. It stands for the 25-year-gift of the Class of 1953, whose Reunion Gift Chairman, Richard P. Simmons, is standing proudly by. That total came from over 56 per cent of the Class, the highest participation in a 25th-reunion gift in the history of the Institute. (Photo: Calvin Campbell)

together at M.I.T. Day at the Hollywood Bowl to hear Arthur Fieldler and the "Pops." I look forward to the concert and to hearing from all of you out there. — **Samuel Rubinoritz**, Secretary, 3 Bowser Rd., Lexington, Mass, 02173; Assistant Secretaries: **Mark Franklin**, Alton Litho Printers, 362 W. Garvey, Monterey Park, Calif.; **Paul H. Grady**, 16 Brook Ln., Westport, Conn. 06880; **Gregor J. Gentleman, Jr.**, Swanson Gentleman, Inc., 818 S.W. 9th St., Des Moines, Iowa 50309

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Dana Ferguson is off once again to see the world. A card has arrived with a postmark from New Delhi, India, saying that he is "back on his usual hard work checking on travel tours this time in Nepal and Bhutan with springtime in the Himalayas." . . . **Jack Larks** writes that he has had two papers accepted for presentation at the Sixth International Conference for the Society of Experimental Stress Analysis in Munich, Germany in September, 1978. . . . **Wesley Haywood** notes that he is still recuperating from his heart attacks and is doing fairly well, doing much reading and thinking.

Robert O. Dobbs of 3965 Guereville Road, Santa Rosa, Calif., died on August 23, 1969. Mr. Dobbs studied geology (Course 12) with the Class of 1952. . . . A letter has come from Holiday House, Montego Bay, Jamaica, from Mrs. George W. Stetson, Jr., informing us of the death of her son Mr. **George W. Stetson III**, of the Class of '52 on August 14, 1977. Shortly before his death George had attended his 25th Class Reunion and very much enjoyed seeing all his old friends and attending the various class activities. George was a consulting mechanical engineer and manufacturer's representative, and a graduate of Course 2. He was principal engineer with R. W. Beck and Associates of Wellesley, Mass., in 1974, and 1975 was doing power plant work. Prior to that he was with Northern Research and Engineering Corp. in Cambridge. Tiring of the rigorous Massachusetts weather, George retired from active engineering work in the states to the hotel business. He was responsible for the Holiday House hotel, a few minutes from the airport at Montego Bay.

In April, 1977, Colonel **Harold R. Larson** died of leukemia at the U.S. Air Force Academy in Colorado Springs, Colo. Hal started his career as a freshman at M.I.T. in Room 2K in Building 22. He then went on to become a resident of the Baker House and graduated from Course 7, Biology. He took his dental training at Loyola University in Chicago. While at Loyola he met Dorothea, who was then a nurse at Loyola. Hal and Dorothea were married in June, 1957. He was then assigned by the Air Force as a clinic chief in France for three years ending in 1960. The next three years he spent at Fort Campbell, Ky., with the 101st Airborne where he became Colonel Larson, was dental surgeon, and made 60 jumps. Hal then went on to Fort Sam Houston and Fort Bragg, N.C., where he was with the Special Forces. Dorothea writes that he was very proud of that Green Beret. Hal attended the command and staff college at Fort Leavenworth, Kan., and taught at the Service School in Fort Sam Houston from 1965-68. In 1968 and 1969 he was a Dental Surgeon in Pleiku, Vietnam. He then returned to Fort Lewis, Wash., where he was resident. He was Chief of Dental Research at the Walter Reed Army Medical Center at Fort Meade from 1971 to 1976. Hal's leukemia was diagnosed in July of 1975. In 1976 and 1977 he was Dental Officer for all service academies at the U.S. Air Force Academy in Colorado. He worked up to one month before he died. Beside Dorothea he leaves four children, Theresa, who is a sophomore at the University of Northern Colorado; Laura, who has just graduated from high school first in her class and will attend Oral Roberts University; Steve, 10 years old; and Tommy, 6 years old. — **Arthur S. Turner**, Secretary, 175 Lowell St., Carlisle, Mass. 01741; **Richard F. Lacey**, Assistant Secretary, 2340 Cowper St., Palo Alto, Calif. 94301

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Francisco R. DelValle was awarded Mexico's national prize in technology by Mexican President Jose Lopez Portillo for development of simple and inexpensive technologies for the production of high-nutrition, low-cost foods. These awards constitute Mexico's highest recognition to persons making outstanding contributions to the country and its citizens. Dr. DelValle of the University of Chihuahua, Mexico, is Visiting Professor of Food Engineering in M.I.T.'s Department of Nutrition and Food Science. . . . **Paul Gray** was elected to the board of directors of Arthur D. Little, Inc. . . . Dr. **Jerry Cohen**, formerly Chairman of Material Sciences and Engineering at Northwestern, has recently rotated back to the Department to concentrate on teaching and research. Jerry has invented a device to be used in the field for rapid measurement of residual stress in metals, and he is in the final stages of building a working model. Jerry will be at our 25th in June.

Dr. **Richard McKee** sold out McKee Pederson Instruments after 13 years in the business and moved to Oregon last July. He is now teaching business policy at the Oregon State University School of Business, a role that he finds both interesting and challenging. . . . **Peter Butt** writes from the Phillipines that he is Owner/President of the Tierra Development Co. engaged in building construction. His eldest son Ken is now married and working for the firm, and his daughter plans to finish her studies in the U.S. in September. . . . We are saddened to report the passing of two of our classmates: **John C. Murkland** of Greenwich, Conn., and **Eldred G. Blakewood** of Baton Rouge, La.

Bob Anslow writes from California that we are approaching our 25th Reunion. Please be ready to support the class gift program generously when you are contacted. Remember, a five-year pledge for 1980-84 counts toward our gift. Also, if your company has a matching gift program, please use it — it counts as well. — **Dave Howes**, Secretary, Box 66, Carlisle, Mass. 01741; Assistant Secretaries: **Lou Mahoney**, 6 Danby Rd., Stoneham, Mass. 02180 and **Chuck Masison**, 76 Spellman Rd., Westwood, Mass. 02190

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After something of a pause we are pleased to report a number of recent happenings.

First, two of the 100 engineers elected this year to membership in the National Academy of Engineering are among our number. **Russell G. Meyerand, Jr.** was elected to membership in the Academy for pioneering work in "gas breakdown at optical frequencies and developments of high-power gas lasers" at United Technologies Corp. where he is the Director of Research. Russ graduated from Course VI in 1955 and thereafter received his master's and Sc.D. degrees from Course XXII. He joined United as Principal Scientist for Plasma Physics in 1958 and has been Director of Research since 1967.

Robert L. Coble, who received his Sc.D. in metallurgy in 1955, was also elected to the Academy. Dr. Coble, who is a Professor of Ceramics at the Institute, received recognition for his contribution to the theory of sintering of materials and to ceramic processing.

For those who are not aware, election to the Academy is the highest professional distinction which can be conferred on an engineer, honoring those who have made important contributions to or who have demonstrated unusual accomplishments in engineering fields.

We have also heard from **Martin Shooman** who reports that he is currently Professor of Electrical Engineering and Computer Science at Polytechnic Institute of New York. During 1977 Marty received two I.E.E.E. Best Paper awards and the 1977 Annual I.E.E.E. Reliability Award for "Outstanding Contributions to Reliability Engineering Education and Pioneering Research in Software Reliability."

Herman Jacobs tells us that all is well, that he

shared a weekend seminar with Leo Moore, '37, last spring, and that he has a second book in the works. Bud also skied Switzerland this year "mostly on my backside."

Allan J. Boardman reports from Woodland Hills, Calif., that he is still with Aerospace Corp. and that all is well. Since we find his comments as to his continued well-being to be newsworthy in themselves, we accept his blessings.

We have received accounts of the diverse fields into which some have wandered: **Bill Friedman** reports that he was elected President of Younker Bros., Inc., a mid-West retailing giant, in May, 1977. Bill also received an M.I.T. Leadership Award in December, 1977. His older daughter Julie has just completed her freshman year at Newcomb College of Tulane University. Bill, I look forward to meeting you on the steps of the Beverly Wilshire once again when you are in L.A. on your next buying trip.

Arnold Langberg reports that his family is enjoying its third year in the mountains of Colorado. Arnie is the Principal of the Evergreen Open Living School and Mountain Open High School, a public alternative school from pre-school to 12th grade, located 25 miles west of Denver. Sounds like an impressive job for a former iconoclast, Arnie. It also sounds as if he can use all the assistance which his wife Dagnija and their children Richard (14), Lars (13) and Krista (12) are providing in connection with the school. Arnie reports, too, that the children are becoming accomplished downhill skiers while Dag and he have turned to cross-country. Getting old, huh?

We have also received a copy of an article from the *New England Fashion Retailer* describing the Judith Carole Curio, a jewelry store in Faneuil Hall Marketplace in Boston, a family operation to which **Roger Reiss**, Course II, lends his assistance. Roger, a Stone and Webster engineer by day, is a retailer by night and weekends at the store overseen by his wife Judith Carole Reiss and managed by their daughter Ronde. Roger also designs the store's brass key rings, one design for which he has a patent (hurrah!). Roger suggests that a note as to his diverse interests might help people think of engineers as "people and not mechanical wind-up toys." Of course, we already know!

One last personal note — your New York correspondent will be a Beverly Hills correspondent for the next year or so. The pharmaceutical patent litigation in which I have labored for the past five years will be reached for trial this fall, and I have dragged wife, children and Siberian Husky to Beverly Hills for the next school year. After that, who knows? In any event, I look forward to being in closer touch with some members of the California contingent soon.

Co-secretaries: **Marc S. Gross**, 321 S. Roxbury Dr., Beverly Hills, Calif. 90212; and **Allan C. Schell**, 19 Wedgemere Ave., Winchester, Mass.

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Professor **Karl Dunipace** has accepted the position of Chairman of the Engineering Division at Purdue's School of Engineering and Technology in Indianapolis. . . . **Marc Forest** reports that he has changed from G.M. Overseas to Detroit Diesel Allison International. He has moved back to the U.S. and will travel overseas. . . . Mobil's internal publication, *Mobil World*, in April carried a picture and story about **Walt Frey** and other members of an aviation products team who recently visited China. . . . **Joseph Gaziano** is President of Tyco Laboratories in Exeter, N.H., and has gained considerable fame for his tenacious attempts to acquire Leeds and Northrup. He was also the subject of a front page bio-article in the May 18 *Wall Street Journal*.

Joe Murgio is president of his own company, Telescience Computer Systems of Fairfield, N.J., a subsidiary of TeleSciences, Inc. . . . The *Needham* (Mass.) *Times* reports that **Phil Trussell** just missed becoming an assessor of the town. That job might get hazardous duty pay these days. . . . The National Academy of Engineering has elected **Andrew Viterbi** to membership. Andrew is with Linkabit Corp. of San Diego and was cited for his contribution to communication and coding. . . . **Ed Zoolalian** writes that he is still with Neff Instrument in California and is in the process of laying out a new plant for the company.

Following is a summary of news of classmates in Israel that Warren has accumulated while in Greece: Dr. **Richard Mateles** is Professor of applied microbiology at the Hebrew University. He lives in Jerusalem with his wife Roslyn and three daughters. They plan to be in the U.S. on sabbatical during 1978-79. Dr. **Dan Khoushy** is a consulting engineer in Haifa, where he owns both a minicomputer and a sailboat. They have three children, and the oldest daughter is now in the army. Dr. **Elhanan Ronat** and his classmate/wife Dr. **Judy Gorenstein Ronat** live in Rehovoth where he is Professor of Physics at the Weizmann Institute. Judy is a psychiatrist with the local health service. **Jack Auslaender** is with the Ministry of Defense in Haifa. His wife Leah is a physician. They have five children — two his, two hers, one theirs. — Co-secretaries: **Bruce B. Bredehoft**, 7100 Lanham Lane, Edina, Minn 55435. **Warren G. Briggs**, 33 Bancroft Rd. Wellesley, Mass. 02181

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With the summer in full bloom as we prepare these notes, we realize that there is less than one year to our 20th Reunion. **Art Collias** and other members of the class in the Boston area will be busy these next few months with plans for next June. If you have any thoughts on the reunion, please drop me a note and some words on what you have been doing.

In this, our 20th year, we are looking for full mailbags. So far, we are starting slow. On the local scene, **Bill Widnall** has left industry for academia by accepting an appointment as Associate Professor of Aeronautics and Astronautics at M.I.T. . . . **Steve Denker**, who has been Regional Director of the M.I.T. Alumni Center in New York, has returned to Cambridge as director of the Alumni Fund. . . . **Pat McGovern**, of International Data Group. based in Newton, has been elected to Young Presidents Organization, a worldwide association of chief executives who have become presidents of sizable companies before the age of 40. . . . **Karl Landstrom** writes from Battelle in Columbus that he has recently been promoted to Principal Research Scientist in the energy and thermal technology section, and **Joe Mogilner** writes from San Diego of the birth of their first child, Samuel.

Let's hear from you this year. It only takes a few minutes to send a line or two to us. — **Phil Richardson**, 180 Riverside Drive, N.Y. 10024; **John Amrein**, 770 Greenwood Ave., Glencoe, Ill. 60022; **Adul Pinsuvana**, A.S.E.A.N. Secretariat, 6 Jalan Taman Pejambon, Jakarta, Indonesia; **Bob Muh**, 907 Chantilly Rd., Los Angeles, Calif. 90024; or **Allan Bufferd**, 8 Whitney Road, Newtonville, Mass. 02160

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We received several letters this month. Its very nice to hear from you all and I am sure that your classmates appreciate hearing from you also. Keep in touch, please.

Rex Thompson, his wife Justine, and their four children are living in Richardson, Tex. They moved there last August after seven years in Houston. Since 1973, Rex has been a "principal" in Purvis and Gertz, Inc., a consulting firm for the energy and petrochemical industries. The whole family likes Texas. He reports a change in vocabulary among the M.I.T. students he meets these days. What we used to call "tools" are now called "turkeys." . . . **Bud Martin**, who lives in Cincinatti, says that although he has recently moved he is still in the phone book and would be pleased to hear from passers-by. Although he doesn't mention where he works, he does say that he has changed over from industrial marketing to consumer products development.

John Baxter reports, "I have rejoined N.C.R. as a Senior Systems Analyst. Also I am in my third year as a World Team Tennis official (line judge). I recently acquired an Apple-II home computer." We would appreciate an evaluation of the machine, John.

Ed Sonn writes, "Since I last wrote I have been extremely busy as Vice President for New Product Development at Data Terminal Systems in Maynard, Mass. The little company of 15 which I joined in 1972 has now grown to over 600 employees and will sell over $40 million worth of electronic cash registers to supermarkets, drug stroes, liquor stores, restaurants, etc. Maybeth and I went to London last March along with 374 employees, spouses, our dealers, and their spouses as a company-paid reward for helping to double profits over the previous year. We are already planning to visit Rome in November, 1978, when D.T.S. plans to take three plane loads on another trip."

Bob Pease sent an article about his pride and joy at National Semiconductor; an extremely temperature-stable monolithic voltage-to-frequency converter. It appears to have the best characteristics commercially available. And its Bob's baby.

Kaare Hoeg is the director of the Norwegian Geotechnical Center where he has been since 1974. Before that he taught at Stanford in civil engineering and at M.I.T.

I am sorry to have to tell you about a death in the class. The Alumni Association informed me of the death of **Jerome Marcus**, but we have no further details. Our deepest condolences to his family.

Lenny Coris received a free trip to Bermuda last April as one of National Life of Vermont's best agents. Congratulations, Lenny.

Lenny's trip makes it easy to bring up my recent trip to Bermuda. I am too poor a sailor to navigate a boat to Bermuda from Newport in the bi-annual Bermuda race, but for the last three races I have found people foolish enough to let me navigate boats back. It is wonderful experience and I recommend it highly. I always bring lots of reading matter and never have a chance to look at it. The open ocean is continually fascinating and if you have good traveling companions, as I have had, a perfect five or six day voyage results. I saw that **Jerry Milgram** navigated one of the major yachts, the *Ondine*, down to Bermuda. He is definitely a classy sailor. In spite of his efforts *Ondine* didn't do any better in its class than my boat in its class. It was great fun, win or lose though. — **Andrew Braun**, Secretary, 464 Heath St., Chestnut Hill, Mass. 02167

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Steven J. Brams, still Professor of Politics at New York University, had his third book, *The Presidential Election Game*, published by Yale University Press in August. . . . **Jerome Winston** writes from Australia that he is busy conducting research-method seminars and workshops for practitioners in various "human service" professions. . . . **Harold M. Waller** has been elected President of the McGill Association of University Teachers. . . . Dr. **George Meyer**, still in the Air Force in Mississippi, will be moving to Washington, D.C., to join the faculty of the Uniformed Services Medical School. . . . **Randall Kunz** announced his candidacy for selectman in Sherborn, Mass., and is currently Corporate Manager of Financial Analysis for Sanders Associates. . . . Dr. **Carl I. Wunsch** was appointed Head of Earth and Planetary Sciences at M.I.T. effective April, 1978. — **Gerald L. Katell**, Secretary, 7 Silverbit Ln., Rolling Hills Estates, Calif. 90274

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This month I am faced with a very unusual dilemma — more news than I can get into a single column. My solution is a simple one — I'll restrict myself this month to pre-reunion news. Then, some time in October or November you can read about the festivities on the Charles last June.

The editors regret an error in the feature on John Wasserlein, '63, for which this picture was first published in Technology Review *for May, 1978 (page B21). The Specialty Paperboard Division, of which Mr. Wasserlein is general manager, is a division of Boise Cascade (and not Scott Paper Co.).*

Last year was a busy one for **Larry Kazanowski**. He was promoted to Director, Technical Environment Evaluation at Ford Motor Co., and his wife Cara gave birth to a baby girl, their first child. The Kazanowskis devote most of their free time to sailing, travel, and the Detroit Institute of Art. . . . **Charley Gardiner** writes that he was married last year and is experiencing the phenomenon of "instant family." Charley, his wife Carol, and three daughters — Chaunee, Cheryl, and Cindy — are now living in the rural farm area of western New York State. Having left the aerospace industry, Charley is now running a Television sales and service business in his home town.

Alan Schwartz reports that he is an associate professor of mathematics at the University of Missouri in St. Louis. . . . **Steve Reznek** and his wife Helle inform us that they are now the parents of a daughter, their second child. . . . **Glen Books** is a partner in the New York law firm of Pennie and Edmonds. Last year he also served on the New York Patent Law Association's subcommittees on litigation and patent law revision, studying current problems in the patent area. I guess that's fair game for a graduate of course VIII. . . . In January **Fran Dyro** was the featured speaker at the capping ceremony for 49 sophomore nursing students at St. Joseph's College in North Windham, Maine, near Portland. Fran, a native of Portland, was honored in 1977 as Maine's outstanding young women of the year.

If you dig out your 1963 *Technique*, on page 35 you will find a picture of **Bob Lanchester** performing in Tech Show. We learn from a news clipping that Bob has continued his acting career, and has progressed from the stages of Kresge to the stages of Broadway. He has also acted in leading roles in some 20 regional theaters. In addition to acting he has directed plays at the Milwaukee Repertory, Guthrie Theater in Minneapolis, Asolo in Florida, and ACT in San Francisco. Last winter Bob directed a New York City stage production, "Count Dracula," by Ted Tiller, at Manhattan's Equity Library Theatre. Bob's production was the New York premiere of the 1971 Tiller play.

A news release informs us that **Dave Stickler** has been appointed Chairman of the Aerophysics Research Committee at Avco Everett Research Lab. Dave has been with the Laboratory since 1973 and has been active in the areas of coal combustion and coal processing. The Aerophysics Research Committee is responsible for the review of research in these and other areas that involve the discipline of fluid mechanics. Dave lives with his wife and three children in Bedford, Mass.

In May Barbara and I got away for a weekend together in Santa Barbara. After sleeping late and going for a run on the beach, we invaded one of the oceanside restaurants for lunch. We each put down a tasty salmon steak and were people-watching (always an interesting pastime in a tourist spot like Santa Barbara) when I found that the group next to us included **Neal Carron**, whom I hadn't seen in 15 years. Neal recognized me, as well, despite the presence of my beard and moustache — paraphernalia I certainly wasn't equipped with in 1963. That evening, over dinner and cocktails, we talked about our lives since leaving the Institute. In many ways Neal's experiences were similar to mine, and probably to many of yours. We were both physics majors. Neal got his Ph.D. from the University of Illinois in high energy physics. Like so many of us, he went the post-doctoral route, spending two years at Rice University in Texas. Finally, in 1971 he left academia, joined Mission Research in Santa Barbara, and has been there ever since. He is still single and spends large portions of his weekends working on the house he bought last year. It was a very pleasant evening, and we promised to do it again on purpose some time.

On Sunday morning, Barbara and I drove up to the Botanical Gardens, in the hills overlooking Santa Barbara. There we ran into **Ed Kanegsberg** and his wife Barbara, also on holiday, sans children. I say that advisedly, because while the Kanegsbergs had left their daughter Debbie at home in Pacific Palisades, Barbara was at the time very pregnant. Please write and tell us, Ed, if it was a boy or a girl.

Well, you might think that was enough in the way of M.I.T. coincidences for one weekend, but there was one more. This one, however, did not involve a classmate. One of the trails in the Gardens was called the Pritchett Trail and was donated by the wife of Henry S. Pritchett to honor that turn-of-the-century M.I.T. president. That is, of course, the same Pritchett for whom Pritchett Lounge in Walker Memorial is named. I shouldn't really be surprised any more by running into classmates here on the West Coast; there are between 50 and 100 of us living in California. That is probably the largest concentration outside of Massachusetts. If any of you are in the Irvine area, please call or come by. Reunion notes next month. Until then — **Mike Bertin,** Secretary, 18022 Gillman St., Irvine, Calif. 92715

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Well, fellow classmates, summer has definitely arrived in D.C., but thank heaven so have some alumni fund envelopes and one class hero. Remember, without your news there cannot be a class of '64 column.

Class Hero — **H. Robert Howie**: Bob acknowledges that this is his first correspondence in 14 years for class notes, not, however, because his life has been uneventful or uninteresting. Indeed, in addition to being a regular and faithful alumni fund contributor and *Technology Review* reader, Bob filled out his work experience at Draper Labs for six years, the U.S. C.I.A. for four years (where he was Division Chief for Advanced Computer Applications), and Ampex for two years (where he was System Development Manager for Terabit Memory Systems). Presently, and for the last two years, he is Vice President of MASSTOR Systems Corporation, a "struggling company of 22 people" formed by Bob and three associates in June, 1976. MASSTOR designs and builds computer mass storage systems (hardware and software) capable of storing and retrieving billions or trillions of bytes of online data for customers such as oil companies, banks, the U.S. Government, etc. Bob chose the word "struggling," not I, and from the tone of his letter, I would have selected "thriving," or at least "growing." As he said in his close, "Know any good MVS system programmers?"

Now to the class notes: **Robert Bachrach** and his wife are the proud parents of a third daughter, Debra Ruth, born last October. In November, Bob was elected a fellow in the American Physical Society. He also received an appointment as a consulting professor to the Stanford Synchrotron Radiation Lab of Physics. . . . Once again, **Leslie Boring** has sent us some news. He was promoted on April 1, 1978, to Resident Vice President of Citibank. (Unfortunately, I cannot find my old class notes to tell me where in the Middle East Les is right now.) . . . **David Dunford** is now Director of the Planning and Economic Analysis Staff of the Bureau of Economic and Business Affairs at the Department of State. David said more important than that is his soccer coaching job. His lifetime record is 13 wins, no losses and one tie. Oh, by the way, his team was all born in 1970!

George Harlem is Director of Marketing for Codex Corp., a subsidiary of Motorola, Inc. His area is Asia, the Pacific, and the Americas. . . . Since November, 1975, **Brian Kashiwagi** has been working in project management at Exxon's Baton Rouge chemical plant, where a partial oxidation unit is being built. The unit makes synthetic gas from liquid hydrocarbons. Brian has been to Frankfurt, Germany, for the process design, New Jersey for the detailed engineering and now Baton Rouge for construction. . . . **Ron Lawson** is now working for Dynatrend Inc., in Burlington, Mass. It's a small company working in several areas that include systems engineering for the Departments of Energy, Defense, and Transportation. Most of Ron's spare time these past two New England winters has been spent shoveling snow off his roof and skiing, in that order.

That's it for envelopes, but we've held aside a press release or two in anticipation of a "dry" envelope month (summer is like that). Please *do* disappoint us and don't let another "dry" month happen for '64 class notes. — **Steve Schlosser**, Secretary, 11129 Deborah Dr., Potomac, Md. 20854

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Summer has come and the Red Sox are running away with the American League; hope it is still true when this is in print! This column has Alumni Fund envelopes to fall back on, but I hope you will now write an essay on how you spent the summer and send it in.

Gloria and **Jim Sprinkle** had their second child, Diana Xochi, in May, 1977, and in August Jim was promoted to Associate Professor of Geological Sciences at the Univeristy of Texas at Austin. For the spring term he has been on leave to finish an N.S.F.-funded research project on fossil echinoderms. Another new arrival announced by Susan and **Peter Klock**; their third son, Felix Stanley, was born January 15, 1978. Dr. Klock is still teaching biology and chemistry at Manchester Community College in Connecticut. Finally, Linda and **Ron Mandle** had their second child, Eric Ben, on March 6, 1978, to join Dara, 3, and "complete the set."

Bruce Fauman is on leave from the University of Rochester, spending the year as Visiting Professor at the University of British Columbia in beautiful Vancouver. A little farther south along the Pacific coast is Dr. **Warren Anderson**, whose enigmatic note I quote in full: "Trouble shooting input-output breakdowns in neuronal networks has led to a vice presidency in Northwest Neurologic Associates, a consulting firm in Portland, Ore., where I live with Elise, 3, Shannon, 1, and Robin, an oriental beauty of indeterminate age."

On the career front, **Dan Diamond** is Manager of Product Marketing, Office Automation Programs, for Honeywell Information Systems. **Charles Gholz** is patent and trademark counsel in the Washington, D.C., law firm of Baker and McKenzie. **Ron Smith**'s firm, Solergy Inc., continues to grow. **Steve Dangel** has left Millipore to become manager of the Machinery Development Department at Dynatech, a consulting firm in Cambridge, Mass.

Michael Graham graduated from medical

school at U.C.-San Francisco in 1976 and followed that with two years of internal medicine residency and is now a resident in nuclear medicine at the University of Washington in Seattle. His wife, Betty, has started Dental School at the university, and the Grahams have one child, Ben, a year old. **Michael Weiss** is "still alive and well in Dallas." He saw **Herb Trachtenberg** and family last August on a trip to Los Angeles. **Greg Schaffer** spent a one-month vacation in New Zealand where he did some mountaineering. He tells us that conditions there differ from those in the U.S. primarily because of the poor weather conditions; even relatively small peaks demand detailed planning and timing.

See you in the fall. As of this writing the family has been expanded by several hamsters, a box turtle and a frog — and the summer has just started! — **Edward P. Hoffer**, Secretary, 12 Upland Rd., Wellesley, Mass. 02181

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Ron Emery has been named assistant actuary and an officer of the United and Accident Insurance Co. Emery joined United Life in 1972 as an actuarial trainee. . . . **Parker Marean** helped form a new marine design firm, Woodin and Marean, Inc.

Ralph Schmitt (vice president, operations, R&G Sloane) writes that he is still making plastic pipe and fittings with volume growing by 30 per cent annually. His family is thriving north of Los Angeles, next to Magic Mountain Amusement Park — "visit us!" His wife Sandy started teaching this year, so the three kids and Ralph are adjusting to women's liberation.

Ned Anderson is Assistant Professor of Mathematics at Kent State University specializing in numerical analysis. . . . **Alan Tobey** writes that he is working as a winemaker and doing new product development for Wine and the People, a small premium winery and the purveyor of the state of the art in home winemaking and brewing in Berkeley, Calif.

Carl Jones III and Lenore (Haas) Jones, '69, writes that their son Matthew was one-year-old on February 17, 1978. Carl is working for Tymshare in Applications Systems Dept. at corporate headquarters in Cupertino, Calif. Nory is working half time for Informatics on the N.A.S.A./Ames wind tunnel project. **Dan Dedrick** and Carolyn (Gissen) Dedrick, '69, visited them in April with their son Benjamin. They are both doctors at Massachusetts General in Boston.

John Freeman is Executive Vice President of Energy Conservation Investments Inc. where he is involved in energy consulting and housing development. . . . **Tim Carney** writes that "After an interesting one and a half years as deputy and Cambodian desk officer in the State Dept.'s Office of Vietnamese, Lao and Cambodian Affairs, I moved into Thai language training in February. Friends will be welcomed at the American Consulate in Udorn, Thailand, from September. The Consular District runs from the Lao to the Cambodian border and promises to be active and amusing."

Bob Silver "joined Polaroid in November, 1977 after over five years with Dupont. We enjoyed being back in the Boston area after ten years absence. I even get to M.I.T. Engineering Library once in a while now. Since it has been totally refurbished, I have a hard time looking casual like I belong!"

Jim Mannos writes that although this notice is a little overdue, he and his wife Ronnie would like to announce the birth of their first child, a baby girl, Stacie Lynne last July. He is currently working at the Analytic Sciences Corp. (T.A.S.C.) in Reading, Mass., in the area of digital image processing, while Ronnie is the director of the Daniels Speech and Language Clinic at the University Hospital in Boston. . . . **Bill Dietrich** recently joined the Municipal Finance Department of Alex. Brown and Sons in Baltimore, Md.

Finally, **Hank Perritt** dropped me a note saying the following: "I continue to enjoy being a railroad lawyer. As Assistant General Counsel of Conrail, I have responsibility for five attorneys and all legal issues related to labor, health and safety, the environment, and law enforcement. You better believe there are plenty of legal issues generated, ranging from locomotive engineers getting arrested in the middle of the night for making too much noise with the train, to threatened strikes by telegraph operators over the introduction of 1930 technology. It's challenging to promote change in an industry that resists change above all. On weekends I fly my Cessna 172 to rise above it all, although a knee injury from skiing has reduced the flying this spring, somewhat." — **Paul Rudovsky**, Secretary, 340 East 64th St., New York, N.Y. 10021

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Ed Riley has left General Electric to operate his own business, Tech Plastics, Inc., which is located in Danvers, Mass., and does custom thermoforming of plastics. . . . Since receiving his Ph.D. from M.I.T. **Donald Paul** has been enjoying life on the beach in southern California. He also does oil and gas exploration research for Chevron Oil Field Research Co. . . . **Ed Geltman** is completing his fellowship in cardiology at Barnes Hospital and will be continuing at Washington University as an instructor in the Department of Medicine and Division of Cardiology. Nancy has completed her master's in social work and is working full time at Barnes Hospital. . . . **Dave Schramm** won the Warner Prize for 1978, which is given by the American Astronomical Society to the outstanding American Astronomer under the age of 35 who has made significant contributions to astronomy during the last five years. The citation reads: "For his incisive and energetic application of nuclear physics to a wide range of astrophysical problems encompassing the entire scale of astronomy from the elemental composition of the solar system to the age and future of the universe." . . . **John Patterson** has been promoted to Lieutenant Commander and, as the Aircraft Maintenance Officer at VAQ-33, is responsible for 16 airplanes and almost 300 officers and men.

Raymond Giglio is finishing work on construction of what must be the last oil-fired generating plant. He and Marsha have started cross-country ski racing and road racing. . . . Susan and **Mark Grossman** have their third child, Jaclyn Dyan, born August 12, 1977. Mark was recently promoted to Director of Business Systems Development at R.C.A. in Princeton, N.J. . . . **Dick Simpson** is splitting his time almost equally among radar astronomy at Stanford, radar astronomy at Arecibo Observatory in Puerto Rico, and backpacking and cross-country skiing in the Sierras. . . . Since September, 1977 **George Starkschall** has been an assistant professor in the Department of Radiological Sciences at the University of Health Sciences, Chicago Medical School. He is responsible for the development of graduate programs in radiological sciences. He and Carol are active in the Sierra Club and are decorating their 100-year-old Victorian Gothic house in Evanston, Ill. — **Jim Swanson**, Secretary, 669 Glen Rd., Danville, Calif. 94526

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Our tenth reunion is now history. About 100 classmates returned to Cambridge for the weekend of June 9-10 and a good time was had by all. The festivities started with a cocktail party and buffet dinner-dance in the M.I.T. Historical Collections. The next day there was a clambake at Duxbury Beach and an evening dance-cruise in Boston Harbor. Remarkably, the weather was excellent for the whole weekend although it could have been a bit warmer at times. The reunion committee, chaired by **Jay Nichols**, did a great job, and for his efforts Jay was elected class president. **Rick Lufkin**, who was responsible for reunion publicity, was elected vice president and the undersigned were re-elected to the position of secretary-treasurer. (Since our coffers continue to be void of any positive assets, the financial chores will be straightforward.)

The award for coming the greatest distance to the reunion goes to Mona and **Gunnar Jacobsen** who came from Oslo, Norway, and were spending three weeks in the U.S. on vacation — Mona's first visit here. A close runner-up was Sonia and **Simeon Masmanian** from London. For those who chose to stay on campus, housing was provided in Burton House which bears no resemblance internally to the building which we knew "way back when." . . . Our own **Owen Franken**, a world traveling professional photographer, documented many of the reunion events and we hope to be able to print some of his pictures soon. We picked up a lot of news at the reunion and will ration it out over the next few months.

This now marks the tenth year of this column, and it may be appropriate to review our methodology. Almost everything we print is from letters you write us or notes accompanying Alumni Fund donations. We try to print almost all the details we receive, excepting obscenities and things which were really intended for personal correspondence. Thus, you the readers are in many senses the authors of the column. We hope you will continue to help out by dropping us occasional notes.

Rick Rudy is now senior quality assurance engineer with Spectra-Physics where he is responsible for representing the company to government regulatory agencies. His outside theater activities include recently directing "Yeomen of the Guard," playing Ko-Ko in "The Mikado" and El Gallo in "The Fantasticks." . . . **Vahe Davidkhanian** is a project manager for a construction company in Iran and was planning to visit the states this summer. . . . **Leonard Mausner** reports the birth of a son, Jesse, now age 1, and a new job as a staff member at Argonne National Lab. . . . **Andrew Seidenfeld** is now in a residency in ophthalmology at the New York Eye and Ear Infirmary. In the same field, **Claude Gerstle** has opened a private practice in Wykoff, N.J.

After receiving a doctorate in math from M.I.T. in August, 1976 ("finally"), **Bob Tinkelman** joined the faculty of Brandeis University as Assistant Professor of Computer Science. . . . **Harry Goldmark** has moved back to Massachusetts to begin a private practice in orthopedic surgery in Leominster. . . . After much traveling abroad for the Agency for International Development, **Susan Downs** has moved to the home office here in Washington where she is section chief for the Sahel Development Program. . . . In Peoria, Ill., **Steve Richards** has joined the architecture firm of Lankton Ziegele Terry and Associates as their resident energy expert. After leaving M.I.T. he joined the Air Force and saw combat in Vietnam as a F-4 pilot. He is continuing his flying now as a pilot in the Illinois Air National Guard. . . . **Steve Finn** is the Director for Network Product Developments for Codex Corp. Steve and Renee live in Framingham with their sons — Jeff, 5, and Dan, 2. . . . That's all we have for now. See you again next month. — **Gail** and **Mike Marcus**, Secretaries, 2207 Reddfield Dr., Falls Church, Va. 22043

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The latest update upon the dynamic increase in sales of plastic kits made by **Wesley Moore**, scion of the Guano Aeroplane and Zeppelin Works, arrived by air mail. He writes that he is active in the M.I.T. Club of Puget Sound, is employed by Boeing and is doing much better than these class notes. . . . **Ron Eisinger** writes that his epistle was misinterpreted — he was with GM and now is working on a Ph.D. at the University of Illinois. Within a month **James Linder** will be teaching legal research and writing at Columbia's Law School, while working toward a doctorate. He has just finished a clerkship with the Sixth Circuit, U.S. Court of Appeals.

Medicine, as usual, has dominated the life of several of our classmates. **Maxim Daamen**, after finishing at Tufts, began his psychiatry practice at the Providence V.A. Hospital and is an instructor at Brown Medical School. **Charles Karaian** is a father and is involved in his internal medicine residency at University of Oregon. **David Kurtz** is

also completing his residency at Beth Israel in radiology.

Fellow metallurgical graduate, **Thomas Caldwell**, lives in Toledo and is automotive marketing manager for the Doehler-Jarvis Casting Division of N.L. Industries. . . . **James Bronfenbrenner** has reason for joy — his wife had twins in July. . . . **Mike Dickens** has not missed New England winters at all. He sells graphics systems for Applicon in California. Formerly, he was employed by them in Burlington, as an engineer. . . . Alexander Schmidt became a member of the **Robert Schmidt** family in 1977. . . . **Rod Walker** is currently working for the Chicago office of American Management Systems, Inc., as a vice president. . . . During the coming academic year, **Michael Kearns** will leave Davis, Calif., to be a lecturer in English at Johannes Gutenberg University in Mainz, W. Germany. . . . **Robert Fleischer** unfortunately had his research project cancelled in Denver and hopes to locate his family in New England prior to the birth of their first child in September.

Robert Gerber has recently married and moved his offices to South Harpsweh. **Larry Griffith** received a Ph.D. in mathematics from Harvard in 1975 and accepted an assistant professorship at the University of Missouri at St. Louis. . . . **Chris Cross** is a partner in Warmrays, a company specializing in residential solar energy use. . . . **Karen Wattel Arenson** continues as Editor of the Markets and Investments Department of *Business Week*, where she covers securities, commodities and Wall Street, in general. . . . **Gregory Arenson** is a member of the New York Bar and does litigation.

The **Vegelers** have enjoyed a hectic summer by traveling to Hilton Head and designing our new house, which we hope to begin construction on this fall. — **Robert Vegeler**, Secretary, 2120 Ft. Wayne National Bank Bldg., Ft. Wayne, Ind. 46802

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I missed an issue of *Technology Review* for which I apologize. I thought I had the copy mailed by the correct date, but I did not. I will try not to let it happen again.

Bruce John Davies, ex-Beta wrestler, is now living in Penobscot, Me., working for Adams Associates, Architects, as a landscape architect in Deer Isle, Me. In April, 1977, he married the former Normandie Koenig of Morristown, N.J. Bruce and Normandie are renting a fine old house on Penobscot Bay, enjoying life by the ocean. Bruce says the peacefulness of Maine suits them fine. His address: Star Route, Box 123, Orland, Me. 04472.

Philip and **Nancy Greene Burstein** write that they had a baby, Rebecca Rose, on January 15, weighing 7lb., 7oz., with a full red head of hair. She is gaining weight like a "young horse and height like a young giraffe. She's just beautiful." Philip and Nancy are finishing their third year in the Purdue Economics Department and are hoping to obtain jobs in the East next year. Congratulations and good luck. . . . Something must be in the air: **William W. Bruml** and his wife Carol have a daughter, Deborah Edythe, born November 2, 1977. . . . In a related matter, **Jonathan Lukoff** is completing his assistant resident year in Pediatrics at Johns Hopkins after which he'll be transferring to U.C.L.A. for his senior residency.

Ralph Brindis writes, "Now finishing my internship at U.C.S.F. in Internal Medicine. Claire and I spend almost all of our time enjoying Seth Louis Brindis, born January 6, 1978 and growing fast. He is presently studying fluid dynamics of breast milk." . . . **Stanley Gilbert** received his M.D. from the University of Virginia in May, 1975. He is at Brooke Army Medical Center, Fort Sam Houston, Tex., and will complete residency in orthopedic surgery in July of 1979. . . . **George F. Providakes** is completing his M.S. in electrical engineering in plasma physics. He entered his Ph.D. program in this June. . . . **Alex Sunguroff** is also at Cornell while his wife Jenny is completing her degree in veterininary medicine.

Marc Roddin writes, "I was working for the ministry of communications of the state of Kuwait during the past year and made three trips around the world between California and Kuwait, vacationing in 14 different countries. Now I'm back in Menlo Park buying a house with the money I made." . . . **Tim Finin** writes, "Janet, I, and now Katie (born in December, 1976) are living in Urbana, Ill. I am working on a Ph.D. in computer science and Janet is working as a computer programmer at the Center for Advanced Computation." . . . I received a flyer from M.I.T. concerning an alleged class of 1971 grad named **Alex Makowski**. He is running for state rep against Melvin King, an M.I.T. Urban Studies professor. This message appears to come from M.I.T., but I imagine it is a ruse by Makowski for extra publicity. For those of you who do not remember or who have tried to forget, Alex was editor of *The Tech* and a Delt. Best of luck, Alex. . . . I wanted to wait until it happened, but with this month's vast amounts of birth announcements, I am happy to announce my wife, Lucy, is expecting in January. Our generation is fortunate to have a choice of whether or not to have children. We are coming to Boston in September, and hope to see some of you then. Please write. — **Hal Moorman**, Secretary, P.O. Box 1808, Brenham, Tex. 77833

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Shirley Wilson writes, "I have just finished my second year teaching math at Auburn University in Montgomery, Ala. Last June I bought a piano and started taking lessons. This summer I am teaching at St. Paul's School (Advanced Studies Program) in Concord, N.H., and camping with friends." . . . **Al Kirkpatrick** reports, "I have been working on a Ph.D. in mechanical engineering at M.I.T. since last September and recently passed my qualifying exams. In order to rest my bloodshot eyes, my wife and I took a two-week hiking trip in Scotland. The year before last was spent at the British Columbia Institute of Technology where I taught mathematics to engineering technicians."

William Shields graduated from Columbia Law School and is now an attorney for the Nuclear Regulatory Commission in Washington. . . . **Eugene Kroch** finished his Ph.D. in economics at Harvard this spring and is starting as an associate professor at Columbia now. . . . **Alan Henricks** left a position as consultant with Arthur Young and Co. to join Atari, Inc., in Sunnyvale, Calif. as Director of Finance of their Consumer Division. . . . **Edward Fox** is starting graduate work at Penn State this fall. . . . **Daniel Nadler** is completing work on an N.I.H. individual postdoctoral fellowship, and will shortly begin a clinical residency in ophthalmology at the New England Medical Center. . . . **Cheryl Hutchins**, after completing a master's in math at the University of Maine, joined the Great Northern Paper Co. in Millinocket, Maine, where she is now administrative assistant to the vice president of operations.

Joe Clift writes, "I have now moved into the operations department at Conrail to use my many ivory-tower-taught talents to right the management wrongs in the real world so that there will be resources to maintain the current overpopulation in ivory towers." . . . From **Larry Marden**, "I am about to complete my fifth year as a consultant for a computer firm in New York City and I still find it challenging. I recently became engaged and will be married in October." . . . **Dennis Biedrzycki** reports, "My wife Jane and I have two children, Mike (2 yrs.) and Tim (8 mos.). I've been working for New England Telephone for five years and just received my M.B.A. from Boston College. I am living in Hanson, Mass."

John Krzywicki writes, "Upon graduation from Harvard Law in 1975, I practiced antitrust and securities litigation in San Francisco. Last summer I returned east to join Cambridge Research Institute, a consulting firm doing general corporate consulting and functioning as economic counsel to law firms in antitrust cases. My first case is located — where else — S.F." . . . **Dan Bloom** got his M.B.A. from Boston University and has a job with the Federal Reserve Bank of Boston. — **Dick Fletcher,** Secretary, 135 West St., Braintree, Mass. 02184

73

A cherry good morning from the Athens of the East here in Boston. A lengthy letter comes from **Bob Cutler** (not to me but to some other class's editor meant for me) which states, among other things, that he is now in Ann Arbor, Mich., "the Athens of the Midwest . . . high prices, lots of rain; reminds me a lot of Cambridge." Bob is in the doctoral program in political science, at the University of Michigan, having finished his M.A. at Penn State. He's studying politics and international relations on the side, and he says *Technology Review* will publish a book review of his later this year.

Buddy Stern is finishing up his intern year at George Washington Medical Center and will — exhausted — be a resident in internal medicine come July 1. . . . **Chaucer Tang** finished his Ph.D. in Chemistry in December, 1977, at Columbia; now is a research chemist at the Central Research and Development Laboratories at duPont's Experimental Station. . . . **Peter Borden** received his Ph.D. from Stanford, the well-known Athens of the Bay Area, in applied physics. . . . **Alan Lawee** writes from his home in Montreal, the Athens of Eastern Canada, that, despite political uncertainty, he is still living it up. He was appointed Manager of Systems support at work, and it "seems more and more certain that I'll never get away from computers." A well-known plaint, indeed!

Chris Tavares was recently appointed a trustee of the National Association of Rocketry and is helping head a national championship club in Virginia. His work has brought him to Cambridge so often that he's joined the M.I.T. Fencing Club! . . . **Nicholas Hamisevicz** writes from the same town, Springfield, Va., the Athens of. . . . , that he is working for Geodynamics Corp., helping the government oversee the development of a text message handling system using distributed minicomputers. . . . **Mark Liss** stopped bowling long enough to tell us he is finishing his internship in internal medicine at Mt. Sinai Hospital. He hoped to be free for the reunion. . . . **Joseph Hadzima** earned his S.M. in management from the Sloan School in 1977, then went on to Harvard Law School where he is now in his second year. . . . Dr. **Jeffrey Harris** was appointed by Governor Dukakis to the Massachusetts Board of Registration and Discipline in Medicine. . . . Gary and **Ann Ezzell** are coping with home, cars, taxes, etc., in Atlanta, and loving it. . . . **Brad Warren** has his master's in Education from Berkeley and planned to visit Alaska in July; he's seeking a job as a high school guidance counselor. . . . **Frans Christ** decided a Ph.D. in mathematics would only get him unemployed, so he is now an Assistant Actuary in Atlanta, the . . . **Gary Holland** is International Busi-ness Manager for Carborundum in Niagara Falls.

Yours pennantfeverishly hasn't done a single thing worth mentioning in months, but what the heck. — **Robert M.O. Sutton**, Secretary, 37 Fairbanks St., Brighton, Mass. 02135 (the Athens of Eastern Mass.)

75

Looks like I have a healthy column this time — many thanks to all of you who have been in touch.

Since receiving his S.M. from Course XVI in August, 1976, **Len Enriquez** has been working for Eastern Airlines in Miami, doing statistics and O.R. studies for the Engineering and Maintenance Division. He says he'd like to correspond with any alumni who knew him. . . . **Diane E. Gilbert** started working at Arthur D. Little in Cambridge this past May. . . . Having gotten his Course XXV Master's, **Scott Fulton** is living in Brookline, Mass., and is working for Amicon, Inc., in the area of novel protein separation techniques. He has become quite active at United Parish in Brookline.

Stan Roth continues to do well at Eastman Kodak in Rochester, N.Y. . . . **George Emerson** is

still working in Disk Products Development at D.E.C. in Mynard, Mass. He occasionally drops in on Sig Ep, at least once a month since he is now Secretary of the S.P.E. Alumni Board. He says that he hopes to see many of you other Sig Ep alumni at next fall's corporation meeting.

Susan Nygard Kronenberger married Edward John Kronenberger (S.B., S.M. Chemical Engineering, 1974) on August 30, 1975. She is presently employed as a geophysicist for Shell Oil Co. in Houston, Tex. Her husband is a chemical engineer for Dow Chemical Co. in Freeport, Tex. They purchased and moved into their first house (one acre lot, even a heated pool) in January 1978. . . . **Caryn Navy** writes, "I got married to **David Holladay** on January 2, 1977. We are living in Madison, Wis. I am in the midst of a Ph.D. program in math, and David is working as a programmer at the Wisconsin Clinical Cancer Center. We would like to hear from friends." Their address is 149 E. Gilman St., Madison, Wis. 53703. . . . **Joe Wrinn** had this to say, "I'm presently working at Teradyne in Boston as an analog design engineer. My wife, Mary, and I reached two important milestones in our lives last year. We bought a house in Quincy and we had our first child. Patrick turned one year old on April 28.

Glenn Keller is in Scotland working on wave power research with Salter at the University of Edinburgh. For those of you who'd like to write, his current address is 38 Liberton Brae, Edinburgh, Scotland. . . . **Frank Klotz** is working for the BDM Corporation in McLean, Va. Currently, most of his work is on a software support contract with the Air Force Data Services Center, Pentagon. He says he's still single and is doing a lot of bike racing these days. . . . I received a nice note from **Joyce Lerner Demain** some time back. She and her husband Chris Demain, '74, are now living in a northwest suburb of Chicago. Chris changed jobs. He's now working for Gould, Inc., as a senior Financial and Planning Analyst. Joyce is temporarily retired from the business world as she has a full time job caring for their son, Brian, who is now nine and a half months old.

I have a message from **Steve Slesinger**, "Note: If **Pete Rubinstein** sees this, I've found a way we can make some money together. Call me — this will repay you for all the water that got dumped on you in strobe lab."

Chuck Livingston writes, "Four math graduates from the class of '75 all moved to Berkeley. Here's the latest. **Jeff Fox** and I are both finishing our third year of graduate work in math at the University of California. **Ru-Mei Kung** is presently working at Lawrence Berkeley Labs and Lila Kobylak Kung, '76, is studying Operations Research at the University. Ru-mei and Lila just had their second child, Yung Ting." . . . **John Eidinger** is just graduating with a M. Eng. from University of California at Berkeley. He spent two years testing rubber foundation bearings to be used to protect buildings from earthquakes. He skied every day this winter at Squaw Valley. He plays golf with **Ernie Brown** and sails with Jerry Raphael, '34. And on top of all that, he struggles at tennis with Don Arkin, '72. By the way, Don spends his time modeling his body for local art students. John will be working for EPS Nuclear in San Francisco after graduation. . . . .**Bruce L. Miller** says that after a couple of years of computer hacking he's decided to go back into physics.

After graduating from Harvard Business School last June, **Curt G. Thiem** went to work for the Lincoln Electric Co. of Cleveland, Ohio. He is now working as a direct sales representative in Minneapolis. His territory includes western Minnesota and all of North Dakota. . . . **Thomas F. McKim** graduated from the University of Chicago Law School in June. He's accepted a position as an associate with a Washington, D.C., law firm and will probably spend most of his time with airline regulation. . . . When he wrote to me in May, **Richard Graves** had this to say, "I am about to graduate from Columbia Law School, where I have been the Managing Editor of the Columbia Journal of Environmental Law. I will be taking the Washington State Bar Exam in July, and will begin work at a medium-sized Seattle law firm (Williams, Lanza, Kastner and Gibbs), where I expect to be involved in antitrust and products liability litigation."

Derry Kabcenell just completed an M.S. in computer science at the University of Michigan, and moved to Los Anglees in June to work for Xerox. . . . .While I'm thinking about the University of Michigan, I saw **Sue Fuhrman** in May, and she will have graduated from the Medical School by the time this goes to print. She and her husband Larry Lasky, '72, have bought an adorable house in Minneapolis, Minn., where Sue will be interning (is that the right term, nowadays?) in pathology. . . . **William S. Dynan** is still a graduate student at the McArdle Lab for Cancer Research at the University of Wisconsin, Madison. He says that he's selling his body to the Medical School piece by piece. He says his M.I.T. Alumni Fund donation is from the proceeds of the sale of the first two pieces.

Bruce J. Davies was married to Normandie Koenig of Morristown, N.J., in April, 1977. He is a landscape architect for Adams Assocaites in Deer Isle, Maine. . . . **Ann K. Gauger**, as of September 1978, will be enrolled at the Scripps Institute for Oceanograpy, La Jolla, in a doctoral program in marine biology.

Unfortunately, I have to end this column on a sad note. I heard from both **Kim Hunter** and Mike Scott, '73, that **Mark Hannig** died in an airplane crash while working in Washington State on April 15, 1978. He was piloting the plane alone through difficult Northwest terrain. — **Jennifer Gordon**, Secretary, 22 Centre St., No. 9, Cambridge, Mass.

76

We are in luck this month with a wide variety of news. While participating in a telethon for the Alumni Fund, I garnered a great deal of info. So. . . .

Sue Litvin has finished up at Sloan and is working for Ford Motor Corp. in corporate finance in Dearborn, Mich. . . . **Mike Baumann** is a grad student at Harvard in economics. He is also doing work at M.I.T. in the energy lab, modeling U.S. coal supply and demand. Mike also told me that **Jim Lambert** is alive and well and living in Philly while going to the Wharton Business School (as is another classmate, **Bernardo Wolfson**).

Brian Tokar has been helping the Clamshell Alliance, working on alternate energy sources. . . . **David Stern** is computer programming to support his music habit — he is trying to make it as a professional musician. . . . **Tom Birney** is now at law school at Boston University and enjoying it. . . . **Larry Deckelbaum** says that surgery is fun. At the time we spoke, he had gotten as far as wiping the blood, holding retractors, and getting yelled at — but he is enjoying it. . . . **Steve Bloxom** is a process engineer for Pulman-Kellogg. . . . **Lance Dunn** is "playing around in the textile field — cloth converting." . . . **Charles Hodgin** is working as a meteorologist for air pollution forecasting for Magma Copper Co. He says that Tucson is an excellent place to live. . . . **Jim Harrison** is currently selling beer and wine and in the fall will be entering the L.B.J. School of Public Affairs at U. of Texas at Austin. . . . **Kathy Whitney** is at veterinary school and likes it a lot (but it will be a lot nicer when she graduates, she says). This summer she worked at the 'Tute in the Division of Lab Animal Medicine.

Dan Duboff has wed Laura DiBartolo and now also has an M.A. in economics from the U. of Iowa. They are planning on coming back East to work and play. . . . **Doug Nutter** is married and is working for G. E. in Pittsfield, Mass. . . . **Joe Tavormina** got an engineer's degree in February. He is now in Atlanta working for Scientific American, a leading manufacturer of microwave and satellite communication systems, as a member of their corporate technical staff. . . . **Fred Tsuchiya** got an M.S. in February and is working for M.T.S. in Minneapolis. By the time this column gets into print he will have wed Candy Macay. **Judy Leider** finished in Food and Nutrition with an S.M. last January. She is enjoying working as a recreational therapist at the Hebrew Rehabilitation Center in Roslindale, Mass, and she is also teaching Self-Designed Fitness with Maggie Lettvin one day each week at the 'Tute. . . . **Bob Lamb** is at Harvard Medical, and is now doing rotations at the Beth Israel Hospital. He told me that **Don Kaplan** is a promising young executive at Polaroid. . . . **Dennis Waldman** is working towards an engineer's degree in Aero and Astro at M.I.T.

Tom Martin has finished at Carnegie-Mellon and is now employed by Arthur D. Little, the Cambridge-based consulting firm. . . . .**Rick Krueger** is working for Corning and playing classical guitar. . . . **H. Mark Carle** is currently unemployed, but will be going to U. of Miami in the fall to study oceanography. . . . **Mary Heinking** is working for Gulf Oil in their Strategic Planning Dept. I hear tell that Mary is on what is known as "the fast track" at Gulf. . . . **Bill Queen** is working for Citibank in Brazil.

And now, moving on to the mail. . . .

Brian Kinney writes that he is in his second year of medical school at Tulane University, and he hopes to be working for a Ph.D. in Course II at M.I.T. in biomedical engineering starting during his elective time at Tulane (the logistics are presenting some difficulties). Aside from the classroom, he says that he has "run in a couple of marathons, been working hard in the hospital, and having a good time." . . . **Bob Fried** is attending S.U.N.Y. Medical School at Albany. . . . From **Sam Gasster**: "Presently at grad school in theoretical physics at U.C./Berkeley. Northern California is enjoyable, but I do miss Boston." **Pete Garcia** is working in D.C. for the U.S. Nuclear Regulatory Commission. His work involves the licensing of uranium mills. . . . **Peter Galitzine** writes that he worked for Xerox Research and Engineering from graduation until February, 1977. He then switched to Hydrotechnic, a consulting firm in water treatment and irrigation which was founded by M.I.T. alumnus Ross Nebolsine, '20. In addition, he "is presently campaigning two roadracing motorcycles on the eastern seaboard." . . . **Greg Malkin** is "alive and well in Cleveland, Ohio — land of fast women, fast cars, and fast food — helping my uncle run a mechanical contracting company."

Jeff Grossman wed Jill Phelps Korn, '78, on August. 20, 1977. Jill was in grad school at Georgia Tech, in Ceramic Engineering. In October, Jeff went off to Officer Basics School in Augusta. After finishing her first quarter Jill took a job with Babcock and Wilcox's Refractories Division in Augusta. Jeff is now working in combat development at the signal school, having completed the S.O.B.C. course. . . . **William Roof** can now be found at Texas A. & M., where he is a grad student in biochemistry. . . . **Chris Garrod** finished his second year at Scripps Institute of Oceanography and is spending time at sea on the Research Vessel *Thomas Melville*. . . . **Mitchell Lazar** writes that he is in his second year in the Medical Scientist Training Program (M.S.T.P.) at Stanford Medical School. . . . **Tevian Dray** reports that he got an M.A. in math in December 1977 from U.C./Berkeley and has been working as a programmer for a business in Portland, Oregon. However, starting in August, he will be at the Max Planck Institute in Munich, Germany, doing physics research on a D.A.A.D. fellowship.

Joe Abeles writes that he took this summer off from Princeton, where he just passed his doctoral qualifying exams in physics. Over the summer Joe worked at the Weizman Institute of Physics in Rehouot, Israel. On life at Princeton, Joe claims that "at Princeton, as everywhere, grad students are pretty inert; this leads to their being walked all over by the administration of the school. I suspect it is more pronounced here than at other universities like M.I.T. with large graduate schools because of the 'high-society undergraduate' dominance here." Anyone else notice this? . . . **Mike Rabkin** writes that he headed for Europe this summer, after finishing psychiatry, obstetrics, and gynecology rotations down at Duke.

Tom Hirasuna and **Jean Hunter** sent a letter with a variety of news. They report meeting **Jerry Mandel** when the M.I.T. Symphony played at Lincoln Center. Jerry now works for Halcon international, a chemical engineering consulting firm.

There was only water in the press room, but the new 1978 officers toast graduation anyway. Left to right: Jim Bidigare, President; Diana Christman, Vice President; Dave Browne, Secretary/Treasurer.

He is living and working in Hackensack, N.J. Tom and Jean write that **Ed Crawley** is getting his S.M. from Course XVI and will be staying for his Ph.D. Also, **Richard Winters** is still at the U. of Oklahoma Medical School and is doing well. And **Tom Parham** is working for Corning Glass Works in Corning, N.Y. Plus, **Bernie Tao** now works for Proctor and Gamble in Jean's former job!

Enclosed with the letter was a clipping from the *N.Y. Times* of May 15. It announced that **Mindy Lipson** is engaged to Paul Aisen (Harvard '75) and that they will wed in December. Mindy and Paul are both students at the College of Physicians and Surgeons, Columbia University.... Also from a newspaper, this time the *Milton Record-Transcript*, a notice that Lt. **Martha Donahue** married Captain Michael Callaway on May 21. Martha is a Management Analysis Officer at the Electronic Systems Division, Hanscom A.F.B.

Lee Gearhart has written me a letter, and enclosed with it is a sentence written 100 times: "**Howie**'s last name is **Tanzman**." Apparently, our now not-so-mysterious Howie at Carnegie-Mellon really jumped on poor Lee, so as punishment the 100 sentences. Howie has finished Carnegie-Mellon's Business School and is working for Ford Finance in Dearborn, Mich. Lee also reports that he "... accepted employment with the Gleason Works, Rochester, N.Y. Come August, I will join them as a Big Frog in their Small But Seemingly Paternal Pond; until then, I'll be here at C.M.U. finishing up my project. Actually, I *hope* to join them in August; as part of my project, I've taken some very fine micrographs showing that hydrogen embrittlement is not affected by microstructure. As my adviser has made his worldwide reputation proving otherwise, I may be here until I learn to take 'correct' micrographs. Science lurches onward...."

Brian Fischer has sent news from the West Coast. He reports that **Eric Steinhauer** and Jeanne Lauterbach, '78, were married on June 25. Jeanne is getting a degree in Industrial Engineering and Eric is getting his M.B.A. — both from Stanford. She'll be working for Southern California Gas, and he'll be working for Ralph M. Parsons, a construction firm based in Southern California. They'll be living in Pasadena.... Eric's roommate, **Bill Petro**, is working on a Direct Electron Counter at S.P.E.A.R. storage ring at the Stanford Linear Accelerator. The hours that he doesn't spend making electron-positron pairs or trying to count them, he's enjoying all the pleasures that California offers. Bill tells me that **Joan Pendleton**, at Stanford for an M.S. in E.E., is spending a lot of time rowing crew and he's seen both **Jim Lindesay** and **Gordon Smith**. Brian is "working for Hewlett-Packard in their Sales Department. We are responsible for assisting sales in our regions, and my region is Europe. Rumor has it I might go to Europe, but I shan't hold my breath. I'm also going to Business School in my spare time."

One Saturday afternoon, I received quite unexpectedly a call from **Mike Sarfatti**. Mike has moved out to San Francisco, where he is working for Standard Oil of California. He told me he bought a new car to go with the new locale, a Fiat X-19 (the sports model). He told me the car is a blast, as is his social life. Plus, he has started a new hobby — getting acquainted with the many different products of some of California's small, fine vintners. I must confess his enthusiasm for San Francisco almost tempted me to forsake Boston (and my business) and rush out there.

And speaking of the fruit of the vine, from the grapevine I learned that **Tom Freeman** and Martha Farah, '77, got married on the Sunday before M.I.T.'s graduation. I was told they started their honeymoon in London. However, that is all I have been able to press out of the noble grape.

Just before these notes were to be submitted, I got a call from **Mike Steckler**. Mike was passing through Boston on his way back to New York. He had got in from Halifax, Nova Scotia, where he was at a meeting of geologists. There, he presented a paper — and had a very good time, including a lot of excellent seafood. He will be publishing his first paper this fall and hopes to go to sea for research again next year.

If more of you wrote (or called) we could have a column of this length every issue. And it would take me just two years to write about *everyone* once. So.... please *write*. — **Arthur J. Carp.**, Secretary, 67 Badger Cir., Milton, Mass. 02186

78

Greetings and congratulations all. This is **David Browne**, your class secretary, news hound and gossip columnist reporting from sunny downtown Cambridge. This is my first attempt at news reporting, so bear with me; it'll take me a few years to get it all right.

We start with news of marriages, listed in no particular order. Two of my good friends and fraternity siblings, **Teresa Costanza** and Daniel A. Nolet, '77, tied the knot in April. The wedding was held in the M.I.T. Chapel and the reception in the Bush Room, complete with a rice shower on the steps of Building 7. The Nolets, still living in Cambridge, will continue at M.I.T. for another year. Teresa will be getting her master's in materials science while Dan works in a research lab.

Other happy couples. **Sam Senne** and **Carol Brown** of East Campus fame were married the day before graduation so that Sam's folks wouldn't have to make two trips from Florida. ... **Janet Freeman** will be married to Peter Cunningham, '77, on August 5 out in Tacoma, Wash. They'll be staying there for a year or so before they return to Cambridge for graduate work.... **Dianna Christman** was married in late June. Unfortunately, I've forgotten her new husband's first name, so congratulations to Mr. and Mrs. Haynie.

Two other classmates and fraternity siblings of mine from Pika, Jay Werb and **Ellen Katz**, were married in Staten Island on June 18 in Jay's parents' back yard. Jay and Ellen will be moving to Philadelphia where Ellen will work in her chosen field of architecture and Jay will go to the University of Pennsylvania Dental School. Before that they are taking an extended honeymoon in Italy where Ellen will point out architectural sights and Jay will point out mistakes in the Europeans' bridgework.

Steve Rice and Leslie Carie, '77, both formerly from Baker House, are planning for their September 2 wedding. Steve will be continuing his graduate study in chemistry.

Rumors have filtered my way about two other weddings: classmates **Gary Dudley** from Burton House on July 16 and **David R. Brown** from PDT. My spies neglected, however, to report the names of their brides (my apologies, ladies). They did report that Dave will be going to medical school at Albert Einstein in New York City. (Please take note, the new husband is David R. Brown, not David S. Browne — we've been mixed up enough.)

Bill Lasser recently announced his engagement to his fiancee Soozie from Silver Spring, Md. Bill will remain in Cambridge to study political science at Harvard.... **Mark Bye**'s fraternity brothers tossed him into the river just before graduation to celebrate his pinning his girlfriend. Mark will be continuing at M.I.T. for his master's in chemical engineering.

Fellowships. Congratulations are due to dozens of people I'm sure, but I'll just run down a few. **Sue Coppersmith** collected fellowships by the bucketfull this year; included in the laurels were a Hertz, a Bell, an N.S.F. and several offers from physics graduate schools. Sue will be studying next year in Cambridge, England, under a Chamberlain Fellowship.... **Gerry Epstein** pulled in a Hertz also; he'll be studying physics at Berkeley, along with **Joel Orloff**.... Other Hertz Fellows were **Paul Lagace**, who'll be staying at M.I.T. in Aero and Astro, and **Brian Stephenson,** who will go to Stanford for graduate work in materials science.

The collections for the class gift went very well, totaling over $850, with over a quarter of the class participating. This money was expanded to $1,700 through gift matching funds from the Alumni Association. Then, during Technology Week events one alumnus was so glad to hear of our fund raising that he added another $1,000 to make our total $2,700. Plans are in the works right now and we hope to have our gift placed in Lobby 7 by fall.

That's all the news right now, but before I end I must make a plea for assistance. Although I'm always out looking for news and my spies lurk everywhere, I sometimes flub (or fudge) the details. I need news from the horse's mouth, so to speak. So write to me soon, tell me about your travels to Inner Mongolia, Paris, London, or even Yonkers; tell me about your jobs, schools, love life, anything — I love to get mail. I'll be at the University of Michigan Law School in Ann Arbor. — **David S. Browne**, Secretary, Room P-21, 551 South State St., Ann Arbor, Mich. 48109

I
Civil Engineering

William G. Hamlin, S.M. '42, has been appointed associate executive vice president of the Air Pollution Control Association, a technical society. . . . **Benedict F. Alexander,** S.M. '65, is president of Alexander Enterprises Ltd., an engineering and construction firm operating out of Stephenville, Nfld., Canada. Ben writes that he operates two hunting and fishing camps in the province, flies his own float aircraft and enjoys playing hockey and golf with wife Heather and sons Don and Greg . . . **George Bugliarello,** Sc.D. '59, elected Fellow of the American Association for the Advancement of Science.

New appointments have been announced in the department: **Hilary Max Irvine** as assistant professor. He is a recognized expert in the area of cable-supported structures; **Michael D. Meyer,** Ph.D. '78, as assistant professor; **Marie-Elisabeth Pate,** as assistant professor. She will teach and do research in economic and public policy aspects of major facility construction with special emphasis on earthquake effects mitigation; **Yosef Sheffi,** as assistant professor. Dr. Sheffi's major field of interest is transportation system analysis; **Daniele Veneziano,** as associate professor. Dr. Veneziano is known for his expertise in probability theory and its application to many civil engineering problems.

II
Mechanical Engineering

Louis F. Coffin, Sc.D. '49, staff scientist and consultant for the General Electric Co. Research Laboratory, has received the Award of Merit naming him a Fellow from the American Society for Testing and Materials . . . **Joseph Ku,** S.M. '65, has started Universal MicroPrinters, Inc., that sells a 200 characters/second dot matrix printhead, an original design by the company . . . **Rich Vanderpoel,** S.M. '71, writes that he is a senior engineer at the Research and Analysis Department of American Bosch Corp. . . . **Guido Danieli,** M.E. '74, is Professore Incaricato of Power Engineering at the University of Calabria . . . We note with regret the passing of **Jon Kelly,** Sc.D. '61, professor of mechanical engineering at the University of Lowell at the time of his death.

III
Materials Science

Joseph F. Gracyzk, Ph.D. '68, is co-author of "Oriented Epitaxial Films of (NMP) (TCNQ)," published in the *I.B.M. Journal of Research and Development* . . . **Shri N. Singh,** Sc.D. '66, has been presented with U.S. Steel Research Laboratory's Recognition of Achievement Award for "development of special annular nozzle for continuous casting of aluminum-killed steels." He also has a patent on the subject . . . **Robert Mainhardt,** '48, is co-founder, president and board chairman of M. B. associates in California.

Rodney E. Hanneman, Ph.D. '61, manager of the Materials Characterization Laboratory at the General Electric Research and Development Center, is the recipient of the Alumni Achievement Award from Washington State University. During his career at General Electric, he has specialized in high-pressure materials and applications of high-temperature thermodynamics and materials science to a wide range of technological problems . . . **John W. Lyons,** Mt.E. '57, and **John A. Stern,** S.M. '41, have been elected Fellows of the American Association for the Advancement of Science.

Institute Professor, Emeritus, **Cyril Stanley Smith,** Sc.D. '26, was this year's John Wulff lecturer. His lecture, titled "The Structure of All Things" dealt with matter and history . . . **Gregory B. Stephenson,** a graduate student in the department has been awarded a National Science Foundation Fellowship.

IV
Architecture

Florian V. Buttlar, M.A.A. '74, informs us that he is teaching and researching in the Department of Architecture at the Technical University in West Berlin, Germany . . . **Philip G. Freelon,** '77, works for John D. Latimer and Associates in Durham, and starts teaching an architectural design studio at North Carolina State University in the fall . . . **Barbara Putnam,** '77 is an architectural designer for Total Environmental Action in Harrisville, N.H. . . . A note from **Alva Tabor, 3rd,** M.Ar. '77, reads: "Since my graduation I have devoted full time to energy research design and education as a founding member of a federally supported technical group, Energy Task Force, Inc. The task force aids New York City housing groups in developing low-cost solar and energy conservation systems for rehabilitated apartment buildings." . . . **Marc Z. Flamm,** M.Ar. '75, is with Building Technology, Inc. in Silver Spring, Maryland. His work there recently brought him to Jerusalem, where he developed an architectural program for housing for the elderly.

Three graduates of the new S.M. degree program in film and video are among the recipients of artist fellowships awarded by the Massachusetts Arts and Humanities Foundation: **Ross McElwee** for his cinema verite portrait of his mother, "Mom"; **Mark Rance,** for "Charleen," a portrait of Charleen Whisnant, protegee of Ezra Pound; **Michael Mossner** for his videotape work "Movement Studies." . . . **Peter R. Altroggen,** has been awarded a National Science Foundation Fellowship.

At the age of 70, Albert G. H. Dietz, '32, Professor of Building Engineering, Emeritus, is still making important contributions to the field of building construction and materials in which he is considered a world authority. But 70 years is an important milestone, so the Department of Architecture late last spring organized a special exhibit to recount Professor Dietz' many contributions. With Professor and Mrs. Dietz in the picture is William L. Porter, Ph.D. '69, Dean of the School of Architecture and Planning. (Photo: Calvin Campbell)

V

Chemistry

Emily L. Wick, Ph.D. '51, dean of the faculty and professor of chemistry at Mount Holyoke College, has been elected to the M.I.T. Corporation . . . **Joe G. Norman,** Ph.D. '72, is one of the recipients of grants from a new program administered by Lawrence Berkeley Laboratory. The program serves the advancement of computational methods in chemistry research . . . **John T. Viola,** Ph.D. '67, has moved to Hanscom A.F.B. He is acquisition management officer with a unit of the Air Force Systems Command . . . **Irving M. Goldman,** Ph.D. '57, with the Pfizer Co. since 1960, has been appointed a research advisor in Chemical Process Research in the Company's Groton laboratories. The position is the highest scientific ranking in the company's Central Research division. The appointment reflects his contributions to penicillin process research and development.

F. J. Martin

Frederick J. Martin, Ph.D. '41, has been appointed manager of the Combustion Technology Unit at the General Electric Research and Development Center. In his new position, Dr. Martin will head a group of chemists and engineers studying the chemistry and physics of flames, and the effects of combustion on the atmosphere . . . The Connecticut College Board of Trustees has elected **Gerald D. Laubach,** Ph.D. '50 as board chairman. Dr. Laubach is president of Pfizer, Inc. and director of the Loctite Corp. . . . **James J. Bishop,** Ph.D. '69, associate dean for student affairs at M.I.T., has been appointed dean of students at Amherst College .

Sharon L. Johnson, Ph.D. '59, has been appointed research associate professor at Polytechnic Institute of New York, and her husband **Joseph E. Johnson,** Ph.D. '59 is manager of engineering at Semiconductor Division of Westinghouse Electric Co. . . . **A. James Diefenderfer,** Ph.D. '61, has moved from Old Dominion University in Virginia to California to assume the post of Dean of Mathematics, Science and Engineering at California State University .

George M. Whitesides, professor in the department, has been elected member of the National Academy of Sciences . . . **Dietmar Seyferth,** also professor in the department, has been elected Fellow of the American Association for the Advancement of Science . . . **John J. Ottusch,** a graduate student, has been awarded a National Science Foundation Fellowship . . . A newly elected Fellow of the American Academy of Arts and Sciences is **John M. Deutch,** professor in the department.

VI

Electrical Engineering

Avery H. Hevesh, S.M. '63, principal staff engineer in the reliability/maintainability design assurance department at Raytheon Co., has been elected Fellow of The American Society for Quality Control with the citation "for continuing effort in promoting better practice and understanding of reliability and quality control engineering disciplines through technical publications, teaching and the application of advance principles to the analysis of complex systems." . . . **George M. Walsh,** S.B. '60, a Raytheon Co. engineer, has been named a consulting engineer in the company's Submarine Signal Division. The position as consulting engineer is given in special recognition of continually outstanding research or engineering achievements over a long period of time . . . **Edward E. David, Jr.,** Sc.D. '47, president of Exxon Research and Engineering Co. explains in *Forbes* where he wants to direct his company in the future. His plans include the building of "clean energy centers" based on coal, that would supply energy and coal-derived chemicals to industry within a radius of 40 to 50 miles.

The following have been elected fellows of the Institute of Electrical and Electronics Engineers: **Jonathan Allen,** Ph.D. '68, "for contributions to the design of computer architecture for signal processing and to the synthesis of speech from text."; **John M. Fluke,** S.M. '36, for contributions to electronic instrumentation."; **Gene F. Franklin,** S.M. '52, "for leadership in engineering education and for outstanding contributions in control theory and applications."; **Robert M. Morris,** S.M. '50, "for contributions to the understanding of radio noise and corona on high-voltage transmission lines."; **Charles A. Zraket,** S.M. '53, "for technical management and contributions in the application of systems engineering to large military and civilian problems."

In 1916, the World War I hospital ship, Britannic, struck a mine and sank, off the Greek coast. Using a side scan sonar tow fish, **Harold "Doc" Edgerton,** institute professor emeritus, found the sunken remains of the ship while hunting for treasure with Jacques Cousteau. It all resulted in a television special, "Calypso's Search For The Britannic." . . . Newly elected members of the National Academy of Sciences are: **Robert M. Fano,** Ford professor, and **Ivan E. Sutherland,** Ph.D. '63, professor and head of the department of computer science at California Institute of Technology.

VI-A

Cooperative Program in Electrical Engineering and Computer Science

This spring's VI-A Class is the largest in the 61-year history of the program. In announcing the final enrollment of 78 new students, Mr. Tucker complimented the participating cooperative companies for their continued support and for the expansion of the program.

The 142 students who applied for admission to VI-A this spring represented 54.2 per cent of the sophomores in Course VI, an increase of 1.5 per cent over last year. The total enrollment in the VI-A Program as of June, 1978, will be 218 students (including both undergraduate and graduate students). Sixty-four of the new students will begin their 1st VI-A work assignments this summer; the remaining 14 will go out in the fall term.

Members of this year's 50th Reunion Class were on campus for Technology Day on June 8. Many VI-A alumni attended the departmental reception that afternoon. It is especially significant that the Bell System joined VI-A in 1926 and the Class of 1928 was the first to graduate VI-A students from the Communications Option with Bell System experience.

Electro 78, the I.E.E.E.'s international electronics convention held in Boston this year, featured two affiliates of the VI-A Program. **Bernard M. Gordon,** '48, Chairman and Technical Director of Analogic Corp., was the keynote speaker at the opening Electro Luncheon on May 22. Mr. Gordon was a VI-A student at the Philco Corp. while at M.I.T.

Addressing a special meeting of I.E.E.E. life members at Electro 78 was Dr. **Eugene W. Boehne,** '28. Dr. Boehne served as administrator of the Cooperative course in electrical engineering (VI-A) at M.I.T. from 1947 to 1960. He then was Director of Research for the I.T.E. Circuit Breaker Co. until his retirement. He now lives in

Florida and is still very active on several I.E.E.E. national committees.

Receiving the first quantum electronics award, given by the newly formed I.E.E.E. Quantum Electronics and Applications Society, is Dr. **A. Gardner Fox,** '34, who recently retired after 43 years with Bell Laboratories, Inc. Dr. Fox enrolled in the Communications Option in Course VI and did his VI-A work with the General Electric Co. prior to joining the Bell System. He took part in the pioneering of the Bell System's first microwave radio relay system in 1944 and holds 53 patents in the microwave and quantum electronics fields.

Three new VI-A faculty advisors have been announced by Director Tucker. Prof. **Robert L. Kyhl,** Ph.D. '47, will handle the Charles Stark Draper Laboratory. Prof. **William M. Siebert,** '46, will be the advisor to Hewlett-Packard's Medical Products Group Divisions in Andover, Mass., and Waltham, Mass. Prof. **Joseph Weizenbaum** will be the advisor to the I.B.M. Corp.'s research facilities at Endicott and Yorktown Heights, N.Y.

Two current VI-A students received high honors this spring: **James A. Roskind,** '78, (VI-A at Bell Labs.) has been awarded a coveted Hertz Foundation Fellowship; **Jeannette M. Wing,** '78, (VI-A at Bell Labs.) and this year's President of M.I.T.'s Tau Beta Pi Chapter, has been elected to Phi Beta Kappa.

Recent visitors to the VI-A Office have included: **Alan H. Katz,** '75, (VI-A with Texas Instruments, Inc.) who is now studying at Tulane Law School in New Orleans, La.; **Algis S. Leveckis,** '76, (VI-A with Naval Surface Weapons Center) who is currently a project engineer at Procter and Gamble Co., Cincinnati, Ohio (Al was married in September '77) and **Robert C. Sherrick,** '76, (VI-A with General Electric Co. in Schenectady, N.Y.) who is now a staff scientist with System Planning Corp., Washington, D.C.

At a cookout given by **Geoffrey J. Bunza,** '74, Mr. Tucker met **Bradford E. Hampson,** '75, (VI-A with H-P/Med.) who is with Prime Computer, Inc., at their new headquarters location in Newton, Mass.; and **Lawrence Kernan,** '76, (VI-A with Honeywell Info. Sys.) who is studying at the Harvard Business School. Geoff (VI-A with Digital Equipment Corp.) is currently on his Ph.D. program at M.I.T. — **John A. Tucker,** Director, VI-A Program, Room 38-473, M.I.T., Cambridge.

VII
Life Sciences

Sandra Hilliker, Ph.D. '74, has been appointed a visiting assistant professor of biology at Bucknell University. Dr. Hilliker specializes in microbiology and molecular biology.

Joan E. Hooper, a graduate student, has been awarded a National Science Foundation fellowship . . . Dr. Chaim Weizmann postdoctoral fellows have been selected. Among them are: **David L. Steffen,** postdoctoral fellow; **Christine L. Truitt,** postdoctoral fellow; **Kevin M. Ulmer,** a graduate student in the Woods Hole Oceanographic Institution Joint Program in biological oceanography . . . The department announces the appointment of two new assistant professors: **H. Robert Horvitz,** '68. Dr. Horvitz has done postdoctoral study at the Medical Research Council Laboratory of Molecular Biology in Cambridge, England; and **Alexander J. Varshavsky,** most recently junior scientist at the Institute of Molecular Biology . . . **Howard Green,** institute professor of cell biology, has been elected a member of the National Academy of Sciences.

VIII
Physics

Donald P. Merrifield, Ph.D. '62, president of Loyola Marymount University, has been elected president of the Association of Independent California Colleges and Universities. Father Merrifield has a broad background as a scholar, teacher, scientist, and churchman. Beside physics he also holds degrees in philosophy and sacred theology . . . **Aaron Temkin,** Ph.D. '56, has become head of the Atomic Physics Office of the Laboratory for Astronomy and Solar Physics, a division of the Goddard Space Flight Center . . . **Hans Mark,** Ph.D. '54, has been elected a Fellow of the American Association for Advancement of Science.

Donald R. Young, Ph.D. '49, is co-author of "Characterization of Electron Traps in Aluminum-Implanted SiO_2", recently published in the *I.B.M. Journal of Research and Development.* Dr. Young is manager of interface physics at the Thomas J. Watson Research Center . . . **Robert N. Noyce,** Ph.D. '53, chairman of the board of Intel Corp., is co-recipient of the Harry Goode Memorial Award, presented by the American Federation of Information Processing Societies, Inc. The award is given in honor of Dr. Noyce's and Gordon E. Moore's original contributions to semiconductor integrated circuit technology.

Michael V. Hynes, a graduate student and **Peter W. Stephens,** a research associate, have been selected Dr. Chaim Weizmann postdoctoral Fellows . . . **Allan S. Jacobs,** has been awarded a National Science Foundation Fellowship . . . **Roman Jackiw,** professor of physics, and **Peter A. Wolfe,** professor of physics and director of research laboratory of electronics, have been elected members of the American Academy of Arts and Sciences.

IX
Psychology

Elizabeth Burdash, S.M. '64, is currently teaching psychology at the College of San Mateo, San Mateo, Calif., including a course in women's studies, Psychology of Women.

X
Chemical Engineering

James R. Katzer, Ph.D. '70, has been promoted to full professor in chemical engineering at the University of Delaware. Dr. Katzer is director of the Center for Catalytic Science . . . **F. A. L. Holloway,** Sc.D. '39, and **Donald E. Smith,** S.M. '53, have been elected Fellows of the American Association for the Advancement of Science . . . **Gabriel Averinos,** S.M. '75, is back with Exxon in Linden, N.J., after two years in France and England where he worked for Esso and studied international business for an M.B.A. degree.

James Wei, head of the department, was a member of a group of nine chemists and chemical engineers from the United States who visited the People's Republic of China in May. The delegation was the first in its field to make a trip under a six-year-old exchange program between the two countries. They spent three-and-a-half weeks visiting scientific and educational institutions and industries . . . **Yu-Ling Cheng,** a graduate student, has been awarded a National Science Foundation Fellowship.

XI
Urban Studies and Planning

Joanna Hirst, M.C.P. '71 is vice president of a real estate development and brokerage firm in northern Virginia. The company is currently involved in developing an industrial park and a retail office complex. Ms. Hirst also writes for *The Washington Post* on real estate and urban planning issues . . . **Owen W. Burnham,** M.C.P. '51, is a planner for Utah Seismic Safety Advisory Council, where he assists local governments in responding to seismic hazards and recognizing sensitive seismic areas . . . **Mary Breuer,** M.C.P. '72, writes from St. Louis that she is a management consul-

A. Javan

Davis (Power Steering) Professorship to Javan

Ali Javan, who as Director of the Optical and Infrared Laser Laboratory is considered one of the world's leading figures in laser science and engineering, is now Francis Wright Davis Professor of Physics at M.I.T.

It's a new professorship named in honor of the donor, among whose 40 patentable inventions was the first power-assisted steering device for an automobile; that was in 1924, and nearly a quarter of a century elapsed before the device came into its own and the late Dr. Davis began collecting royalties.

Dr. Javan joined M.I.T. in 1961 after coming to the U.S. from his native Teheran in 1949. His major contributions to laser science began at Bell Telephone Laboratories, where in 1959 he developed the first gaseous laser. Since then, at M.I.T., his work has spawned several fields of active new research and important industrial applications. He holds several patents and a series of major awards: the Stuart Ballantine Medal of the Franklin Institute (1962), the Fanny and John Hertz Foundation Award (1966), the Frederic Ives Medal of the Optical Society of America (1975), and the Outstanding Patent Award of the Research and Development Council of New Jersey (1977).

Econometric System Modeling Returns

TROLL (Time-Shared Reactive On-Line Laboratory), born in 1966 as a project of the M.I.T. Department of Economics, is back at the Institute.

Since 1971 TROLL has been funded by the National Science Foundation and operated by the National Bureau of Economic Research as an interuniversity project — the Computer Research Center for Economics and Management Science. In those seven years it's grown into "probably the most powerful and sophisticated econometric modeling system in the world," used by research throughout the U.S.

Now TROLL and its parent, renamed the Center for Computational Research in Economics and Management Science, are part of the Sloan School of Management. Professor Edwin Kuh, who originated the TROLL project in 1966, remains as Director, and he welcomes inquiries concerning its use.

C. I. Wunsch

Oceanographer Wunsch Heads Earth Sciences Department

Now it's official: **Carl I. Wunsch,** '62, Cecil and Ida Green Professor of Physical Oceanography who has been Acting Head of the Department of Earth and Planetary Sciences, is Head of the Department.

Dr. Wunsch is a specialist in ocean processes — tides, currents, and their interrelationships in the dynamics and circulation of the seas; his research includes a combination of theoretical studies and practical observations — including, most recently, deep-sea moored arrays in the North Atlantic and Indian Oceans.

Dr. Wunsch has been Acting Head of the Department since Frank Press resigned to become President Jimmy Carter's Science Adviser. He studied mathematics (S.B.) and geophysics (Ph.D.) at M.I.T. and joined the faculty immediately upon completing graduate study in 1966. Since then, Dr. Wunsch has been honored by the James B. MacElwane Award of the American Geophysical Union (1971) and the Texas Instruments Foundation Founders Prize (1975) and by designation as Fellow by the Royal Astronomical Society and the American Geophysical Union.

tant with Ernst and Ernst Co. Before that she spent four years in Great Britain working as a planner with the New Town program . . . **James R. Devanney,** M.C.P. '71, has started a wood stove store in Cincinnati. The store specializes in high efficiency wood heaters and solar equipment.

Lawrence E. Susskind, Ph.D. '73, has been named head of the department. Dr. Susskind is widely known for his pioneering work in the development of new approaches to citizen participation in local decisionmaking . . . **Margaret E. Dewar,** a doctoral candidate, has been awarded a National Science Foundation Fellowship.

XII

Earth and Planetary Sciences

William C. Phinney, '53, spent commencement weekend celebrating his 25th Class Reunion. He is now chief of the geology branch of N.A.S.A. in Houston. . . . **James H. Natland,** '68, returned for his 10th Class Reunion and reported that he is now an assistant geologist on the Deep Drilling Project at Scripps Institution of Oceanography, from which he received a Ph.D. in 1975. He is married to Carol (Edgerton) Natland, a relative of M.I.T.'s Emeritus Professor Harold E. Edgerton. . . . **James D. Kolb,** '53, president of Texlan Oil Co., Inc., in Tyler, Tex., visited the Department during commencement weekend.

O. Frank Tuttle's, Ph.D. '48, home address is 4850 West Lazy C Dr., Tucson, Ariz. 85705, where he is enjoying retirement. . . . **Kazi E. Hag,** Sc.D. '54, writes: "When the N.A.S.A. Electronic Research Center at Cambridge was closed in 1970, most of us of the research group were left without jobs. Fortunately for me, a position in the physics department of Southeastern Massachusetts University came along, and I moved to Dartmouth from Concord. I am now a tenured professor of physics, conducting research in solid state physics. I am settled in a home in Dartmouth with my wife and three children." His home address is: 1 John Winthrop St., N. Dartmouth, Mass. 02747. . . . **André J. Kermabon,** S.M. '56, President of SYMINEX (systèmes d'exploration minerale), 15 Boulevard Cieussa 13262, Marseille Cedex 2, writes: "As for my situation, I started my own company in 1973. Our main activities are instrumentation and structural monitoring of offshore production platforms in the North Sea. We study the vibratory modes of the structures to detect possible weak points. This is currently our primary activity and we have at the moment extensions in Great Britain, Brazil and Montreal, Canada."

Herbert S. Jacobson, '54, married Jackelaine Peek in Bangkok, Thailand, in 1964 and left that country in 1966 to do geological work in Turkey, Guyana and Bolivia. In 1970 they settled in Arizona, where Jackelaine has a horse farm and they own a five-acre ranch on the outskirts of Tucson. The Jacobsons now have two daughters, Diana Lynn (12) and Deborah Ann (11). Herbert is currently employed by the Minerals Exploration Co. and is active as an exploration geologist and project manager for that company in the Southwest. His present address is Route 14, Box 6005, Tucson, Ariz. 85704.

Ferris Webster, Ph.D. '61, has taken leave of his position as Associate Director for Research at the Woods Hole Oceanographic Institution to serve as Assistant Administrator for Research and Development at the National Oceanographic and Atmospheric Administration (N.O.A.A.) in Washington, D.C. He is the first person to be appointed to this recently established position. . . . **Raymond D. Watts,** graduate student in Course XII from 1966-68, writes that he completed his doctoral work at the University of Toronto with former Course XII Professor David Strangway and is now employed with the United States Geological Survey in Denver.

Notice has come from his widow, Gladys, that **Walter Stoll,** Sc.D. '42, died in Madrid, Spain, on June 5, 1978. He was a consulting geologist and mining engineer there and was also associated with the Faculdad de Ciencias, Universidad de Madrid.

In spite of the inadvertent omission of Professor Gene Simmons' minibiography from page 13 of the recently updated Course XII Alumni Register, it can be reported that he and his students are as active as ever on the third floor of the Green Building. And his name does appear on page 12 in the list of "Current Full-time Course XII Faculty." — **Robert R. Shrock,** Professor Emeritus, Room 54-1026, Cambridge, Mass. 02139.

XIII

Ocean Engineering

William M. Dubbs, Oc.E. '74, has been promoted from senior project engineer to proposal manager at C. E. Lummus . . . We have received a note from **Rob Winkler,** S.B. '76. He is an officer on a nuclear class attack submarine, the Cincinnati. He also wants to pass on a greeting to Jackie Findlay and Judy DiGennaro . . . **Frank C. Anderson,** N.E. '53, is president of Industrial Electric Co., Inc. and of I.E.C.O. Corp. . . . **Edward F. McCann,** N.E. '70, is manager of the maintenance and repair division of Chevron Shipping Co., with responsibility for worldwide supertanker repair.

John M. Reade, S.M. '69, has been named manager of resource recovery systems for the environmental products department of Air Products and Chemicals, Inc. . . . **James A. Fay,** S.M. '47 and **Donald E. Davis,** S.M. '56 have been elected Fellows of the American Association for the Advancement of Science.

Joao M. de Oliveira, has been promoted to assistant professor. He has been a research assistant and instructor since 1975 and is working toward a doctoral degree . . . **Paul C. Xirouchakis,** has also been appointed assistant professor. He expects his Ph.D. in January.

XIV

Economics

Glenn T. Hammons, S.M. '71, having completed his M.D. at the University Washington School of Medicine in 1976, is now at Barnes Hospital, St. Louis, for his residency in pathology . . . **Jeffrey M. Perloff,** Ph.D. '76, is now Assistant Professor of Economics at the University of Pennsylvania.

After a three-year study financed by the National Science Foundation, **Howard Kunreuther,** Ph.D. '65, of the University of Pennsylvania concludes that many Americans use insurance not as protection but investment; instead of insuring themselves against high losses, they opt for insurance policies that cover more probable small losses on which they're "sure to collect." Hence the low public participation in such government programs as flood and earthquake insurance. Professor Kunreuther's findings, after three years of research, are in *Disaster Insurance Protection: Public Policy Lessons* (400 pp., $20.95) published by John Wiley & Sons, Inc.

Elections: **Aaron J. Gellman,** Ph.D. '68, and **Kurt W. Back,** Ph.D. '49, to Fellows of the American Association for the Advancement of Science . . . Professor **Peter A. Diamond,** Ph.D. '63, to Fellow of the American Academy of Arts and Sciences . . . **Harold H. Kelley,** Ph.D. '48, to member of the National Academy of Sciences.

XV

Management

Beginning this fall, **Pamela W. Turner,** Director of Recruitment and Placement and Manager of the Accelerated Master's Program at the Sloan School, has the additional title of Lecturer, which means that she will be doing part-time teaching in her field of management information systems, planning, and control.

New appointments: **E. Per Sorensen,** S.M. '76,

E. P. Sorensen

P. A. Strassmann

S. A. Landon

P. R. Marsilius

to Development Manager in the Fuel Gas Department, Natural Resources Group, Dravo Corp. . . . **Paul A. Strassmann,** S.M. '55, to Vice President — Information Products Group, Xerox Corp., Greenwich, Conn. . . . **Stephen A. Landon,** S.M. '68, to Vice President — Financial Management Analysis, Intercontinental Hotels Corp. . . . **Dean E. Bensley,** S.M. '55, Director of the Air Traffic Control Directorate, Equipment Division, Raytheon Co., to Vice President of the Company . . . **Edward V. Fielding,** S.M. '74, to General Manager of Seminole Sugar Corp. and Pahokee Produce, Inc., Palm Beach, Fla. . . . **Toby Mannheimer,** S.M. '77, to Staff Assistant to the Corporate Vice President — Corporate Organization and Human Resources, Bendix Corp. . . . **John F. Harkness,** S.M. '64, to General Manager, Plastics Division, Harvey Hubbell, Inc., Newtown, Conn. . . . **Lester H. Nathan,** S.M. '77, to management trainee at Leviton Manufacturing Co., Providence, R.I. . . . **Arnold Herzog,** Ph.D. '75, to the faculty of the College of Business Administration, University of Maine.

To **Philip R. Marsilius,** S.M. '48, President of Producto Machine Co., Bridgeport, Conn., the Joseph A. Siegel Memorial Award of the Society of Manufacturing Engineers for "his distinguished Presidency" of that Society.

Paul M. Konnersman, S.M. '67, is founder and President of the Konnersman Group, Marblehead, Mass., brokers representing either builders or purchasers in the sale of yachts.

Terry W. Rothermel, Ph.D. '73, Senior Consultant at Arthur D. Little, Inc., spoke on "The Environment and the Economy — Myths and Realities" before the New Hampshire Chapter of the National Association of Accountants late last spring.

J. Scott Armstrong, Ph.D. '68, Associate Professor in the Wharton School, University of Pennsylvania, is the author of *Long-Range Forecasting: From Crystal Ball to Computer* (612 pp., $24.95). John Wiley & Sons, Inc., publishers, describe the book as "lucidly and persuasively outlining all the ways managers, politicians, and social planners predict the future. . . . comprehensive but witty . . ."

From his wife Phyllis we learn of the death on December 15, 1977, of **Alan T. Hundert,** S.M. '62, in Mt. Kisco, N.Y. **John Marshall,** S.M. '73, of West Chester, Penn., died on May 19, 1978, in Cheshire, Conn.

Sloan Fellows

Allen L. Torpie, S.M. '71, to Vice President — Marketing, Communications Products Operation, General Cable Corp., Greenwich, Conn. . . . **Edward W. Kissel,** S.M. '75, formerly Manager of the Windsor (N.H.) Shoe Products Plant of Goodyear Tire and Rubber Co., has been transferred to the corporate headquarters of Goodyear International Corp., anticipating an eventual overseas assignment . . . **Peter E. Viemeister,** S.M. '69, to Director of the South Carolina Energy Research Institute and Chairman of its Research and Development Committee . . . **Trevor A. Fisk,** S.M. '76, to Vice President — Business, Systems, and Marketing, Cooper Medical Center, Camden, N.J. . . . **Robert E. Fenton,** S.M. '77, Assistant Professor of Management on the adjunct faculty of the University of Baltimore, promoted to Commander, U.S. Coast Guard, and made Chief of the Policy and Review Branch, Contracting and Procurement Division, U.S.C.G. Headquarters. . . . **Michael Campbell,** S.M. '76, is Founder of SCARAB, a Boston-area consulting firm specializing in new-venture start-ups and international market investments . . . Having merged his firm into Dynatrend, Inc., Burlington, Mass., **Albert J. Gravallese,** S.M. '68, is now Vice President of Dynatrend, Inc.; he's also been promoted to Captain in the Naval Reserve and is Commander of the Seventh Reserve Naval Construction Regiment, Civil Engineer Corps. . . . **Robert F. Calman,** S.M. '67, Executive Vice President of IU International Corp., to Director.

Senior Executives

Glen A. Williamson, '72, to Vice President — OEM Sales, Communications Products Operation, General Cable Corp.

XVI

Aeronautics and Astronautics

William S. Widnall, Sc.D. '66, joins the faculty this fall as Associate Professor, teaching in the field of guidance and control. Dr. Widnall went to work at the Draper Laboratory while a graduate student, making major contributions to guidance and control for the Apollo missions. Then in 1969 he became Manager of the Department of Navigation, Guidance, and Control at Intermetrics, a firm formed by a group of Draper Laboratory engineers

Herman P. Schutten, S.M. '64, has been named Director of Advanced Concepts for Cutler-Hammer, Inc., Milwaukee, Wisc. . . . **Rodger K. Vance,** S.M. '67, is the Director of Facilities Engineering at Rockwell International, Pittsburgh, Penn. . . . **Alan L. Weinberger,** S.M. '61, has been promoted to Department Manager, Systems Programming, at Sperry Systems Management's Reston Engineering Center, Reston, Va.

The Air Force Systems Command's prestigious General B. A. Schriever Award has been presented to **Robert W. King,** Ph.D. '75, for his paper entitled "An Improved Value of the Earth's Gravitational Constant from Analysis of Lunar-Laser Ranging Data." The award honors the most outstanding technical achievement by a company-grade officer.

Philip D. Shutler, S.M. '64, has been promoted to the rank of Lieutenant General, U.S. Marine Corps, and assigned as Director, J-3, Office of the Joint Chiefs of Staff. . . . First Lieutenant **Thomas M. Humes,** S.M. '76, U.S.A.F., is a weapons system officer stationed at Lakenheath R.A.F. Station, England. . . . Commander **Thomas F. Wiener,** Sc.D. '62, U.S.N., is Program Manager in

Since the founding of the Sloan Automotive Laboratory, 454 names have appeared as authors of its theses, project reports, and technical papers — a prodigious outpouring of technology on internal combustion engines and aircraft propulsion systems. Almost all of these authors remember Professor C. Fayette Taylor, '29, with respect and affection; he taught in mechanical and aeronautical engineering for 34 years beginning in 1926 — until his retirement in 1960. But the greatest beneficiaries of "the Taylor discipline" were his thesis students, and on June 7 some 40 of them and their guests joined to surprise Professor Taylor with a party.

Irenee du Pont, Jr., '43 — he's handing Professor Taylor a tool with which to open a package in the picture at the top right — headed the sponsoring committee, and Rear Admiral Alfred B. Metsger, S.M. '40, who presided — in the picture above — gave Professor Taylor a bound volume containing messages of affection and good wishes from many of his former students. In his invitation, Mr. du Pont had said that Professor Taylor "is still 'going strong,'" and none of the evening's guests could doubt it. (Photos: Gordon R. Haff, '79)

the Strategic Technology Office, Advanced Research Projects Agency, Washington.

Mel L. Swartz, S.M. '77, is a staff engineer on inertial guidance systems engineering at Draper Laboratory. . . . **John Hopkins,** S.M. '76, is with the Defense Mapping Agency's Aerospace Center, working on applications of inertial technology to geodetic science. . . . **Richard V. Warden,** S.M. '59, President of Raytheon Marine Co. and Sorensen Co., heads the 1978 Cancer Crusade in Manchester, N.H. . . . Many activities reported by **Peter M. Bainum,** S.M. '60, Professor of Mechanical Engineering at Howard University: Vice President — Publications of the American Astronautical Society; initiated into Sigma Xi, 1978; and faculty adviser to the Howard University Chapter Student Branch of A.I.A.A., cited for the A.I.A.A. Outstanding Student Branch Award, 1977.

Two deaths among graduate alumni of the Department have been reported, but no further information is available: **Stanley E. Ellison,** S.M. '50, in August, 1977; and **Otto F. Meyer, Jr.,** S.M. '50, on November 28, 1977.

XVII
Political Science

Stephen P. Chilton, Ph.D. '77, is Chief Division Methodologist, Education and Public Welfare Division, Congressional Research Service (Library of Congress); following his avocation, he recently spoke on moral development research and its application to political development at a national conference on moral development and politics. . . . **Gayle D. Hannah,** Ph.D. '69, free-lance writer and technical graphic layout designer, has formed a new company, Edugraphics. . . . **Richard A. Rettig,** Ph.D. '67, Senior Social Scientist at Rand Corp., is author of *Cancer Crusade: The Story of the National Cancer Act of 1971* (Princeton University Press, 1977). . . . Professors **Walter D. Burnham** and **Suzanne Berger** were elected members of the National American Academy of Arts and Sciences late last spring.

XVIII
Mathematics

Three mathematicians have joined the Department as Assistant Professors:

☐ **Sy David Friedman,** Ph.D. '76, formerly L. E. Dickson Instructor in Mathematics at the University of Chicago; Dr. Friedman's field is mathematical logic, his M.I.T. degree having been with Professor Gerald E. Sacks.

☐ **Gary L. Miller,** formerly Assistant Professor of Mathematics at the University of Rochester. Dr. Miller, whose Ph.D. is from the University of California (Berkeley), is credited with an efficient algorithm for testing the primality of integers that requires Reimann's hypothesis for the proof of correctness; his research deals in general with finding such efficient problem-solving algorithms.

☐ **Adi Shamir,** formerly Instructor in Applied Mathematics at M.I.T. Dr. Shamir came to M.I.T. last year after finishing his doctorate in computer science at the Weizmann Institute of Science.

Professors **Felix E. Browder,** '46, of the University of Chicago and **Gian-Carlo Rota** were among 200 distinguished scientists elected Fellows of the American Association for the Advancement of Science early last spring.

Four members of the Class of 1978 receiving degrees in mathematics have National Science Foundation Fellowships for graduate study starting this fall. They were among 32 N.S.F. Fellowship winners at M.I.T., the largest number in any U.S. university. . . . Professor **Bertram Kostant** was elected to membership in the National Academy of Sciences late last spring.

XIX
Meteorology

Richard J. Reed, Sc.D. '49, Professor of Atmospheric Sciences at the University of Washington, Seattle, was elected to membership in the National Academy of Sciences late last spring . . . **David L. Roberts,** S.M. '60, is now Director of Deferred Giving at Colby College, Waterville, Maine. . . . Formerly at the Air Force Geophysics Laboratory, Bedford, Mass., **Stephen Mudrick,** Ph.D. '73, is now Assistant Professor in the Department of Atmospheric Science, University of Missouri, Columbia, Mo.

XXII
Nuclear Engineering

Robert P. Morgan, S.M. '59, Chairman of the Department of Technology and Human Affairs and Director of the Center for Development Technology at Washington University, St. Louis, received the $1,000 Chester F. Carlson Award of the American Society for Engineering Education in June in Vancouver; he was honored for "innovative leadership in uniting elements of the social sciences, natural sciences, and engineering to provide a new kind of education for technology and human affairs."

George E. Dials, S.M. '73, is Environmental Manager of Addington Brothers Mining, Inc., a subsidiary of Ashland Coal, Inc., Ashland, Ky. . . . **Craig A. Chambers,** U.S.N. (S.M. '75), is Division Officer aboard the U.S.S. Nautilus, the world's first nuclear-powered submarine. . . . **Jesus A. Taborda,** S.M. '72, is Executive Secretary of the Venezuelan Nuclear Energy Council responsible for planning and implementing nuclear programs in that country. . . . **Thomas Rodack,** S.M. '77, has begun work with the Power Systems Division of Combustion Engineering, Inc., Windsor, Conn.; his first duties include thermal-hydraulic analyses of pressurized-water systems. . . . **James S. Peters,** S.M. '69, is an artist/painter working on murals in Norwich, Conn.

ALUMNI TRAVEL PROGRAM 1978-79

This special travel program, to some of the most interesting areas in the world, has been especially designed for alumni of Harvard, Yale, Princeton, M.I.T., Cornell, Dartmouth, Univ. of Pennsylvania and certain other distinguished universities and for members of their families. It is consciously planned for persons who normally prefer to travel independently, and covers lands and regions where such persons will find it advantageous to travel with a group.

The itineraries are designed for the intelligent traveler, and offer an in- depth view of historic places, ancient civilizations, archeological sites and artistic treasures, as well as interesting and far-flung cultures of the present day and spectacular scenery from virtually the four corners of the globe. The programs are, however, also planned to incorporate generous amounts of leisure time and to avoid unnecessary regimentation so as to preserve as much as possible the freedom of individual travel, while utilizing the savings and the practical convenience which group travel can offer.

Considerable savings have been obtained by using special reduced fares offered by the world's leading scheduled airlines, fares which are generally available only to groups or in conjunction with a qualified tour and which offer savings of as much as $500 and more over normal air fares. In addition, special group rates have been obtained from hotels and sightseeing companies. By combining these savings with a careful selection of the finest available hotels and facilities, it is possible to offer travel arrangements of the highest standard at moderate and economical cost.

AEGEAN ADVENTURE — 23 Days: The archeological treasures of classical antiquity in Greece and Asia Minor and the islands of the Aegean, with visits to Constantinople (Istanbul), Troy, Pergamum, Smyrna (Izmir), Sardis, Ephesus, Epidauros, Mycenae, Olympia, Delphi and Athens, as well as a cruise through the Aegean to the islands of Crete, Santorini, Mykonos, Rhodes and Patmos. Departures April through October.

MEDITERRANEAN ODYSSEY — 22 Days: An adventure into realms of antiquity in the western Mediterranean, with the ruins of Carthage and the Roman cities of Africa in what is now Tunisia, the splendid Greek temples of Sicily (including the famed "Valley of the Temples" at Agrigento and the ruins of Syracuse, the city of Archimedes), the remarkable Norman churches of Palermo, dating from the age of William the Conqueror, and the fortress cities of the Crusader Knights of St. John on the island of Malta. Departures March through October.

VALLEY OF THE NILE — 17 Days: A detailed view of one of the greatest civilizations the world has ever known, the civilization of ancient Egypt along the valley of the Nile. The itinerary includes Cairo, the pyramids of Giza, Sakkara, Dashur and Meidum, Memphis, Abydos, Dendera, the great temples and monuments of Luxor, including the Valley of the Kings and the tomb of Tutankhamun, and a cruise on the Nile of Upper Egypt to visit Esna, Edfu, Kom Ombo and Aswan, as well as the great monumental temples of Abu Simbel near the border of the Sudan. Departures January through December.

THE ORIENT — 29 Days: A magnificent survey of the Orient, including the exotic temples and palaces of Bangkok and the ruins of ancient Ayudhya, the great metropolis of Singapore, the enchanted island of Bali with its unique artistic heritage, the famed port of Hong Kong on the border of Red China, and a comprehensive visit to Japan which places special emphasis on the cultural treasures and the tranquil beauty of classical Japan at the historic city of Kyoto and at Nara, Uji, Kamakura and Nikko, as well as the mountain scenery of the Fuji-Hakone National Park and the modern capital at Tokyo. Optional visits are available to the ancient temples of central Java and the art treasures of the National Palace Museum in Taiwan. Departures March through November.

BEYOND THE JAVA SEA — 32 Days: A remarkable journey through the tropics of the Far East, from the port of Manila in the Philippines to the tea plantations and ancient civilizations of Ceylon, the Malay Peninsula, the Batak tribes of Sumatra, the ancient temple ruins of Java, the fabled island of Bali, headhunter villages in the jungle of Borneo, and the unforgettable beauty of the lights of Hong Kong. Departures January through November.

MOGHUL ADVENTURE — 30 Days: The great historic and cultural heritage of India, combined with the splendor of ancient Persia and a journey into the high Himalayas in the remote mountain kingdom of Nepal: imposing Moghul forts, ancient temples, lavish palaces, the teeming banks of the Ganges, snow-capped mountains, picturesque cities and villages, and the Taj Mahal, culminating with the famous mosques of Isfahan and the 5th century B.C. palace of Darius and Xerxes at Persepolis. Departures January through November.

SOUTH AMERICA — 28 Days: An unusually comprehensive journey through the vast continent of South America, from the Inca ruins and colonial heritage of the western coast, amid the towering snow-capped Andes, to the great Iguassu Falls and the South Atlantic beaches of Brazil. The itinerary includes the colonial cities of Bogota, Quito and Lima, the great Inca centers of Cuzco and Machu Picchu, La Paz and Lake Titicaca, the magnificent Argentine Lake District at Bariloche, Buenos Aires, the Iguassu Falls, Sao Paulo, Brasilia and Rio de Janeiro. Departures January through November.

THE SOUTH PACIFIC — 28 Days: An exceptional tour of Australia and New Zealand, with Maori villages, boiling geysers, fiords and snow-capped mountains, ski plane flights, jet boat rides, sheep ranches, penguins, the real Australian "Outback," historic convict settlements, and the Great Barrier Reef. Visiting Auckland, the "Glowworm Grotto" at Waitomo, Rotorua, the Southern Alps at Mt. Cook, Queenstown, Te Anau, Milford Sound and Christchurch in New Zealand, and Canberra, Tasmania, Melbourne, Alice Springs, Cairns and Sydney in Australia. Optional extensions available to Fiji and Tahiti. Departures January through November.

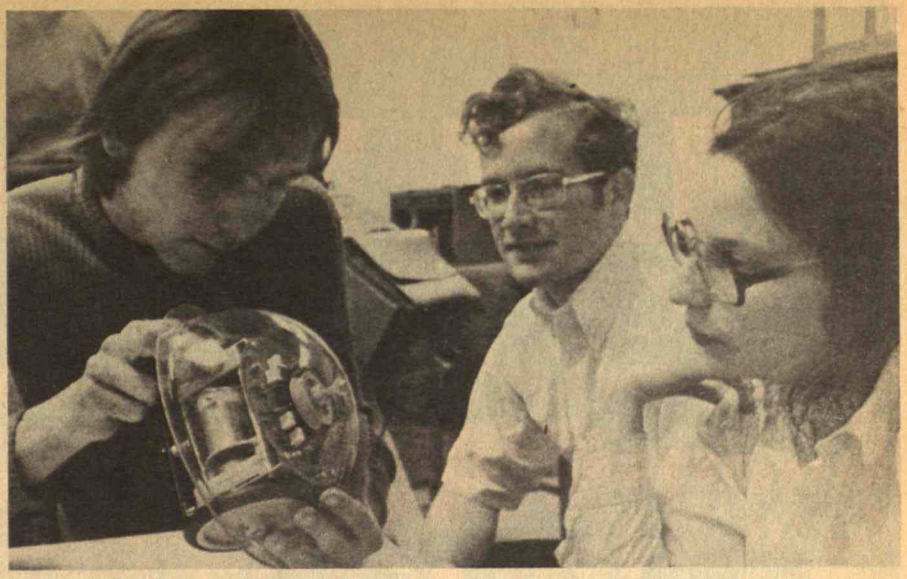
EAST AFRICA — 21 Days: A distinctive game-viewing and photographic safari to the wilds of Africa, covering some of the greatest wildlife areas in the world. From the semi-desert of Kenya's Northern Frontier region and the vast game-filled plains of the south to the lakes of the Great Rift Valley and the snow- capped peak of Kilimanjaro, the itinerary includes Nairobi, the Nairobi National Park, Treetops, Meru National Park, Samburu Game Reserve, the Mt. Kenya Safari Club, Lake Nakuru National Park, Lake Naivasha, an extended stay in the great Masai-Mara Reserve, Amboseli National Park and Tsavo National Park, with optional visits to the coast at Mombasa and Lamu. Departures January through December.

Prices range from $2,295 to $3,575 from U.S. points of departure. Fully descriptive brochures are available on each tour, setting forth the itinerary in detail with departure dates, relevant costs, hotels used, and other information. For full details contact:

ALUMNI FLIGHTS ABROAD

White Plains Plaza, Dept. TR8, One North Broadway, White Plains, N.Y. 10601

Everyone at M.I.T. who knows her thinks of Joanne S. Tobias, '80, as an undergraduate student in biology, a member of Alpha Delta Phi. But to several thousand residents of northeastern Massachusetts she's Miss Merrimack Valley, winner of the contest to qualify entrants in the Miss Massachusetts Pageant held early this summer. Ms. Tobias lost out there, but she's also succeeded in losing any image she may have had as a typical "M.I.T. tool." (Photo: David A. Schaller, '78, from The Tech*)*



W. Daniel Hillis, '78, is tinkering with his Terrapin™ Turtle. Early this year he decided that such a gadget serving as a "physical output device" for a microprocessor would be as much fun for U.S. computer buffs as for him. So he and some friends — including David McClees (center) and Margaret Minksy, '78 — gathered capital to incorporate as Terrapin, Inc. The Turtle, now available in kit or assembled form, acts out its computer's instructions by moving, drawing, blinking, and "talking." It's five inches high, seven inches in diameter, moves at the rate of six inches per second, and turns within its own diameter by moving its wheels in opposite directions. (Photo: Rick Stafford from the Harvard Gazette)

Terrapin, Inc.: A Company Riding on the Back of Its Turtle

If you're one of more than 30,000 Americans — professionals and hobbyists — who own and use a microcomputer, you need a Terrapin™ Turtle for a "physical output device."

"Turtle"-like "robots" have roamed M.I.T. corridors to the amusement of visitors for a decade and more, demonstrating that mobile, self-controlled machines can intelligently deal with problems in three dimensions — finding their way through rooms, following corridors, drawing pictures, travelling to preprogrammed destinations.

Working with such a "robot" one day, W. Daniel Hillis, '78, who received his degree last June from M.I.T. in the field of artificial intelligence, realized that countless computer buffs might like to do what he was doing: let an instrumented, sensitive vehicle in communication with a microcomputer draw maps, teach geometry, demonstrate programming concepts, and otherwise fulfill a computer's assignments. So he called his high school classmate David McClees, who was about to graduate from Harvard; then they called a few more friends, and suddenly there was the capital for a company called Terrapin, Inc., ready to market the Terrapin™ Turtle.

"Dan thought of going into business in part because that's just part of the atmosphere of the computer world now," Mr. McClees (firm President) explains.

As for himself, Mr. McClees says that "when I hear opportunity knocking I try not to slam the door against it."

With its modest working capital, Terrapin, Inc., has built some 125 Turtles which are now for sale — in kit form — for $300 each, or $500 if you want one assembled and ready to go. The goal is to sell 800 by the end of the year.

Meanwhile, Terrapin, Inc., has some other plans on the drawing board — a cordless version of the Turtle which communicates with its computer by sound signals instead of through a cable; Turtle-like devices especially designed for teaching mathematics and computer science in elementary and high schools; and perhaps the logic and electronics for an automatic, robot vacuum cleaner.

Four Years: Time to Grow, to Change, and to Remain the Same

by William Lasser, '78

It rained when we came to the Institute, and it rained when we left: a late summer downpour forced our freshman picnic into Dupont Gymnasium, and an early summer shower greeted us four years later as we left the cage with our diplomas.

It was all somewhat fitting — the water flowing on our caps and gowns and the cool breeze blowing our tassels in our faces, as if to remind us that, while we were correct in thinking that so much had changed from September 1974 to June 1978, a great deal more had remained the same.

Rites of passage characteristically produce mixed feelings; the excitement of moving ahead is always laced with a touch of sadness at leaving what has become the status quo. Commencement, far from being an exception to this rule, is its quintessential example. Every movement, every note of music, every word spoken is calculated to generate this effect, and no one — parent, teacher, graduate, or onlooker — is spared.

Commencement at M.I.T. (the program calls it "Graduation Exercises" and students call it "Graduation") carries this theme to its conclusion in a uniquely M.I.T. way. The ceremony is traditional in its lack of tradition: there are no honorary degrees handed out, no emotional renditions of Elgar's "Pomp and Circumstance," no valedictory speeches (although the class president made a few requisite remarks), and, above all, no wasted effort. Every graduate — from Banse-Fay, Barco, and Bidigare to Theriault, Tochko, and Ulmer — is called by name (actually, first initial and last name, as W. Lasser), and walks proudly and triumphantly across the stage to receive a diploma (but no handshake) from President Wiesner (and, if a Ph.D., a hood from the Chancellor as well); then, anticlimatically, he marches back to his place, flipping his tassel from right to left (or was it left to right?).

President Wiesner delivered the Commencement address, a brief one by Graduation Day standards at other schools. His words were flavored with political sarcasm and a touch of the wry humour one comes to expect, but there was nevertheless an unmistakably serious tone. The President's most serious comment produced the most laughter: the Institute, he said, was glad to get rid of us. And so it must be, for even as we go a new set of freshmen stands ready to take our place.

From Commencement Day on, the members of the Class of '78 are M.I.T. alumni. That distinction carries with it burdens and responsibilities as well as privileges. The theme of the President's speech had been that scientists and engineers must infuse humanity into technology, that the two can never be separated without risk to basic values. Technology can be and surely is taught by M.I.T., even to those whose scientific backgrounds are weak or nonexistent. Humanity must come from something within us that is present as freshmen and which must be nurtured and allowed to grow through four years as undergraduates.

All M.I.T. alumni are bonded by a common educational experience. Still, as we were different upon entering, we remain different upon leaving. Walking in the rain, I realized what I had not known at our freshman picnic: a university can educate, it can transform, it can forever affect its students, but it cannot erase what they bring with them. Nor should it try. An educational institution can never truly teach justice and compassion, it can only stifle or draw out what already exists.

William Lasser, '78, will pursue graduate study in government at Harvard this fall.

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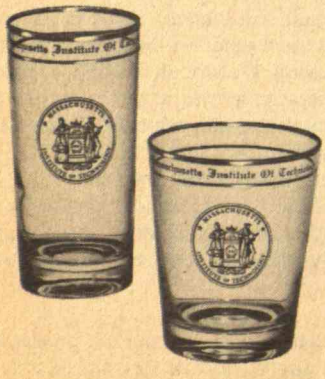

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T. F. Weiss


I. V. Yannas

Nine Promotions to Full Professor

Nine Associate Professors were promoted to the rank of Professor at the end of the 1977-78 academic year; among them are future leaders of the Institute's teaching and research activities. The new Professors are:

☐ **David Botstein,** virologist and geneticist in the Department of Biology. Dr. Botstein has been at M.I.T. since 1967, when he completed his Ph.D. in microbial genetics at the University of Michigan; his undergraduate degree was from Harvard. Dr. Botstein's work in genetics and genetic regulation was recognized by a 1972 Career Development Award from the National Institutes of Health and — early this year — by the prestigious Eli Lilly Award of the American Society for Microbiology. He teaches an undergraduate laboratory course in experimental microbial genetics and a graduate-level course in bacteria and bacterial viruses.

☐ **Rudiger Dornbusch,** an authority on monetary policy and international economics in the Department of Economics. Dr. Dornbusch was born in Germany and educated at the Universities of Geneva and Chicago (M.A. 1968, Ph.D. 1971). He came to M.I.T. as Associate Professor in the Department in 1975, following teaching and research at the Universities of Chicago and Rochester and the London School of Economics. In addition to his M.I.T. assignments in the field of international economics, Professor Dornbusch is Associate Editor of the *Journal of Monetary Economics,* Co-Editor of the *Journal of International Economics,* and consultant to the Federal Reserve Bank, the Council of Economic Advisers, and the International Monetary Fund.

☐ **Shaoul Ezekiel,** Sc.D. '68, a specialist in lasers and their applications in the Departments of Aeronautics and Astronautics and of Electrical Engineering and Computer Science. Dr. Ezekiel's research centers around laser clocks, ultra-high-resolution laser spectroscopy, laser gyroscopes, and nonlinear optics. A native of Iraq, he came to the U.S. following undergraduate study at the Imperial College of Science, London, and industrial work in England and Canada; he joined the Department of Aeronautics and Astronautics after completing his graduate degrees in that field.

☐ **Paul L. Joskow,** an expert in industrial organization and government regulation of industry in the Department of Economics. Professor Joskow studied at Cornell and Yale (Ph.D. 1972), and came to M.I.T.'s faculty immediately thereafter; his current research and teaching include the economics of nuclear energy, economic regulation of hospitals, and anti-trust policy, and he has made major contributions to the computer-based M.I.T. Regional Electricity Model, designed to show the interrelationship between energy price and demand under a wide range of possible future scenarios in the U.S. Dr. Joskow is Co-Editor of the *Bell Journal of Economics.*

☐ **Kenneth C. Russell,** a physical metallurgist in the Department of Materials Science and Engineering. Dr. Russell has done pioneering research on the effects of high-intensity radiations (as in fission and breeder reactors) on metals, a field vital to the design of future energy resources, and he has had a major role in strengthening the Department's graduate programs in the past decade. At M.I.T. since 1964, Dr. Russell studied at the Colorado School of Mines and Carnegie-Mellon University (Ph.D. 1964).

☐ **Gerald E. Schneider,** Ph.D.'66, neuroanatomist in the Department of Psychology. Dr. Schneider began his work on brain damage and its effects on behavior while a graduate student at M.I.T., and he has since become a specialist in neuroanatomical plasticity, behavioral alterations and recovery from brain damage, and the organization of the visual system. His undergraduate work at Wheaton College (Ill.) was in physics.

☐ **Christopher T. Walsh,** an authority in the biochemistry of enzymes, in the Departments of Chemistry and of Biology. Dr. Walsh came to M.I.T. to work in the two departments in which he now teaches in 1972, following undergraduate work at Harvard, graduate study (in the life sciences) at Rockefeller University (Ph.D. 1970), and postdoctoral work at Brandeis University. His research centers on the role of enzymes in chemical reactions, the biochemistry of membranes, and biological toxicology.

☐ **Thomas F. Weiss,** Ph.D. '63, a student of communications biophysics in the Department of Electrical Engineering and Computer Science. Dr. Weiss has combined his interest in communications with important research on the human auditory system, leading him to a specialty in auditory physiology and the biophysics of hearing. In addition to his M.I.T. appointments since 1963, when he joined the faculty, Dr. Weiss has been on the staffs of Harvard Medical School and the Massachusetts Eye and Ear Infirmary since 1964, and he now holds a Career Development Award from the National Institutes of Health.

☐ **Ionnis V. Yannas,** S.M.'59, whose field is the use of polymer materials as human implants, in the Department of Mechanical Engineering, in which he is now Professor of Polymer Science and Engineering. After finishing his Master's degree at M.I.T. in chemical engineering, Dr. Yannis studied physical chemistry at Princeton (S.M. 1965, Ph.D. 1966) and then returned to the Institute as Assistant Professor in the Fibers and Polymers Division of the Department of Mechanical Engineering. Dr. Yannis headed an M.I.T. team which recently developed artificial skin for burn victims and is now working on materials for artificial blood vessels.

A ceremony, as well as a $5,000 honorarium and the obligation of a lecture or lecture series, is a consequence of the Killian Faculty Achievement Award. In the case of the 1978-79 winner, Morris Halle (center), Ferrari P. Ward Professor of Modern Languages and Linguistics, the ceremony was in the President's Office, attended by (left to right) James R. Killian, Jr., '26, Honorary Chairman of the Corporation; Professor Robert I. Hulsizer, Jr., Ph.D. '48, Chairman of the Faculty; Professor Lloyd Rodwin, Chairman of the Faculty's Killian Award Selection Committee; and President Jerome B. Wiesner. (Photo: Margo Woodruff)

Individuals Noteworthy

Kudos at M.I.T.

To **Morris Halle,** Ferrari P. Ward Professor of Modern Languages and Linguistics, the $5,000 James R. Killian, Jr., Faculty Achievement Award for 1978-79; Professor Halle, a scholar in the scientific study of language, will deliver a major lecture in the field of his work during the coming academic year. . . . To **David Baltimore,** American Cancer Society Professor of Microbiology, and **Alexander Rich,** Sedgwick Professor of Biology, membership in the Pontificial Academy of Sciences by decree of Pope Paul VI. . . . To **John D. C. Little,** Professor of Operations Research and Management, the Charles Coolidge Parlin Award of the American Marketing Association. . . . To **Vera Kistiakowsky,** Professor of Physics, the honorary degree of Doctor of Science from her alma mater, Mount Holyoke College; and to Professor **John M. Deutch,** 61, Director of the Office of Energy Research, an honorary Doctor of Science from Amherst College.

Professor **John D. C. Little** will serve as President of the Operations Research Society of America for 1978-79, and **J. Harvey Evans,** Professor of Naval Architecture, is Vice President for three years of the Society of Naval Architects and Marine Engineers. To Professor Emeritus **Jerome C. Hunsaker,** '12, former Head of the Department of Aeronautical Engineering, and Professor Emeritus **C. Richard Soderberg,** former Dean of the School of Engineering, Honorary Life Membership in the Society of Naval Architects and Marine Engineers.

To **Flora N. Katz,** Ph.D.'78, and **Debra S. Knopman,** Luce Scholarships from the Henry Luce Foundation for study in the Far East. . . . To **Cyrus C. Taylor,** '80, a Harry S. Truman Scholarship for continuing study at M.I.T. . . . To **Ruth Perry,** Assistant Professor of Literature, a Fellowship of the Radcliffe Institute for 1978-79.

To **Walle J. H. Nauta,** Institute Professor and Professor of Neuroanatomy, the Boylston Award for Teaching Excellence of the Boylston Society at Harvard Medical School, whose students hear him lecture under the Harvard-M.I.T. Program in Health Sciences and Technology.

M.I.T. Administration Changes

Richard S. Armstrong, '65 formerly Executive Director of Church Financial Service, to Assistant Director of Admissions . . . **D. Steven Blum** to Assistant Staff Writer in Proposals and Publications, Resource Planning . . . **Deborah J. Cohen,** Senior Staff Writer, to Manager of Proposals and Publications in Resource Planning . . . **Roberta A. Carrara,** Business and Personnel Manager of the Development Office, to Assistant to the Director . . . **John T. Fitch,** '52, Director of Technology-Based Educational Development and Marketing for the Center for Advanced Engineering Study, to Executive Director of the Association for Media-Based Continuing Education for Engineers, Atlanta (he will take a one-year leave of absence from M.I.T.) . . . **Donald B. Johnson,** Associate Director since 1974, to Director of the Development Office . . . **Paula Ruth Korn,** news reporter and editor for WENH-TV, Durham, N.H., to Assistant Director of the News Office . . . **Ernst R. Pariser,** Associate Director for Advisory Services of the M.I.T. Sea Grant Program, to Associate Director for Education Coordination in charge of the Sea Grant's educational activities . . . **John T. Preston,** formerly General Manager of EDL Instruments, Inc., Chicago, to Assistant Director of the M.I.T. Associates Program . . . **Barry Rowe,** Manager of Purchasing for the Charles Stark Draper Laboratory, Inc., to Director of Purchasing and Stores. . . . **Malcolm A. Weiss,** who formerly held major responsibilities in research, development, and technical management at Exxon Corp., to Deputy Director of the Energy Laboratory.

Rising and Changing in Business

Ward D. Halverson, '56, appointed manager of the Directed Energy Division of Spire Corp. Dr. Halverson also continues as thesis supervisor in the Department of Physics and as special lecturer in plasma physics courses at M.I.T. . . . **Ivan A. Getting,** '33, former President of The Aerospace Corp., elected to the board of directors of Northrop Corp. . . . **Stephen Weisskoff,** '57, formerly senior planning advisor at Exxon, named President of Phys-Chemical Research Corp. . . . **Solomon Baker,** '39, elected vice president, industrial materials group of Rogers Corp.

William M. Hannan, '52, elected a vice president, in charge of the technical division, of the American Bureau of Shipping . . . **John T. M. Pryke,** '62, appointed manager, new markets development at Compugraphic Corp. . . . **William C. Schneider,** '49, deputy associate administrator for space transportation systems, named associate administrator for space tracking and data systems at N.A.S.A. . . . **Stephen A. Landon,** S.M.'68, most recently director of planning process at PepsiCo., Inc., elected vice president — financial management analysis of Intercontinental Hotels Corp.

Herbert M. Priluck, '59, formerly manager of Maryland's Baltimore region rapid transit project, returns to private engineering practice in Brookline, Mass. . . . **Charles H. Ehlers,** '52, president of the Dewey and Almy Chemical Division of W. R. Grace and Co. appointed Corporate vice president . . . **Howard B. Zasloff,** '52, promoted to vice president and manager of the Lummus Technical Center . . . **David L. Ljungquist,** '66, former product planner, named manager of marketing research at Pitney Bowes.

John D. Alden, '49, previously manager of manpower activities for the Engineers Joint Council and executive secretary of the Engineering Manpower Commission, appointed accreditation director of the Engineers' Council for Professional Development . . . **Albert F. Clear,** '42, president and chief operations officer of the Stanley Works, elected director of the board of Stanley Home Products, Inc. . . . **Philip A. Ruziska,** '62, promoted to chief agricultural chemicals engineer at Exxon Chemical Co.

John M. Cook, '49, former district transportation manager at Bethlehem Steel Corp. moves to the home office as he is appointed manager of transportation services . . . **Dean E. Bensley,** S.M. '55, director of the Air Traffic Control Directorate of Raytheon Co.'s Equipment Division, elected a vice president.

Honors at M.I.T.

Elected Fellows of the American Academy of Arts and Sciences: **Suzanne Berger,** professor of political science; **Walter D. Burnham,** professor of political science; **John M. Deutch,** '61, professor of chemistry; **Peter A. Diamond,** Ph.D. '63, professor of economics; **Roman Jackiw,** professor of physics; **Richard Leacock,** director of motion pictures and cinematography; **Peter A. Wolfe,** director of Research Laboratory of Electronics and professor of physics.

Elected members of the National Academy of Sciences: **Robert M. Fano,** '41, Ford professor of engineering; **Bertram Kostant,** professor of mathematics: **Daniel G. Quillen,** professor of mathematics; **George M. Whitesides,** professor of chemistry; **Carl I. Wunsch,** Cecil and Ida Green professor; **Howard Green,** professor of cell biology. He is also the recipient of the Selman A. Waksman Award in microbiology "for his fundamental contributions to the biology of cultured animal cells."

Kudos: Honors, Awards, Citations

Cecil H. Green, '23, awarded the first Maurice Ewing medal from the Society of Exploration Geophysicists . . . **Grant A. Larsen,** '51, supervising architect at Tudor Engineering Co., elected Fellow of The Construction Specifications Institute . . . **Albert H. Bowker,** '41, Chancellor, University of California, Berkeley, awarded the Shewhart medal by the American Society For Quality Control . . . To **Vincent S. Haneman,** Jr., '47, his second award of the Legion of Merit.

George R. St. Pierre, '51, professor of metallurgical engineering, The Ohio State University's Award for Distinguished Teaching . . . **Peter Homack,** S.M. '41, president of Elson T. Killam Associates, Inc., named honorary Doctor of Engineering at New Jersey Institute of Technology . . . **Leonard Yen,** '73, a Broadcast Music Inc. Award to Student Composers for "Split Ends."

Donald L. Adams, '59, managing director of Administrative Services for the American Institute of Certified Public Accountants, the first annual Joseph J. Wasserman Memorial Award . . . **Alexander Kusko,** Sc.D. '44, president and senior consultant of Alexander Kusko, Inc. Consulting Engineers, named Distinguished Engineering Alumnus of Purdue University's School of Engineering . . . **Dennis D. Buss,** '63, honored by Texas Instruments as a "leading technical innovator."

Elected members of the American Academy of Arts and Sciences: **Robert P. Abelson,** '48, professor of psychology, Yale University; **Gerald H. Kramer,** '59, professor of political science, Yale University; **Bruce C. Murray,** '53, professor of planetary science, California Institute of Technology; **John W. Thibaut,** Ph.D. '49, professor of psychology, University of North Carolina; **George H. Vineyard,** '41, director, Brookhaven National Laboratory.

Elected members of the National Academy of Sciences: **Sidney Darlington,** '29, assistant professor of electrical engineering, University of New Hampshire; **Harold H. Kelley,** Ph.D. '48, director and professor of sociology, University of California at Los Angeles; **Richard J. Reed,** Sc.D. '49, professor of atmospheric sciences, University

of Washington, Seattle; **Ivan E. Sutherland,** Ph.D. '63, professor and head of department of computer science, California Institute of Technology; **Lynn R. Sykes,** '59, professor of geology, Columbia University; **Peter H. vonHippel,** '52, director, Institute of Molecular Biology, University of Oregon; **Shmuel Winograd,** '58, I.B.M. fellow at Thomas Watson Research Center.

Francisco R. Del Valle, '54, visiting professor of food engineering at the University of Chihuahua, Mexico, awarded Mexico's National Prize in Technology, for development of simple and inexpensive technologies for production of high nutrition, low cost foods.

Obituaries

Earle Buckingham, 1888-1978

Earle Buckingham, a member of the Department of Mechanical Engineering from 1925 until his retirement as Professor Emeritus in 1955, died at his home in Springfield, Vt., on June 3; he was 90.

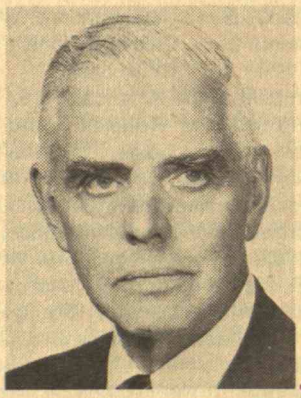
Professor Buckingham's teaching and research were in the field of machine design, and he was widely recognized as an authority on gears and gear systems.

Vera Manganelli, 1903-1978

Vera Manganelli, who retired in 1968 as Administrative Assistant in the Office of the President, died in Falmouth, Mass., on June 8. She had held various administrative and secretarial assignments at M.I.T. for 42 years prior to retirement and was known throughout the Institute community.

Louis Mitchell, 1908-1978

Louis O. Mitchell, who was a member of the staff in the Chemistry Department's Spectroscopy Laboratory working in molecular beam research from 1945 to 1948, died in Naples, Fla., on April 26; he was 70.



J. B. Lampert

James B. Lampert, 1914-1978
Architect of the Leadership Campaign

Lieutenant General James B. Lampert, U.S.A. (Ret)., S.M. '39, Vice President for Resource Development, died in Walter Reed Hospital, Washington, on July 10 following a brief illness; he was 64. Howard A. Johnson, Chairman of the Corporation, described him as "a distinguished colleague . . . who set a towering example of devotion to the Institute."

General Lampert returned to M.I.T. after a distinguished military career to reorganize and lead the Resource Development staff in supporting the $225 million M.I.T. Leadership Campaign in 1972, and since then he has played a key role in planning and coordinating staff activities through nearly three-quarters of the Campaign. He attended meetings of the Corporation, was a member of the Corporation's Development Committee where he was a frequent speaker, and participated in Institute policymaking as a member of the Academic Council.

"General Lampert's courtly modesty, self-effacing manner, and innate decency will always be exemplary of the qualities of mind and spirit we hold high at M.I.T.," Mr. Johnson wrote members of the Corporation in notifying them of the loss. "He had a profound understanding of education, of business and industry, and of the structure and operation of government. . . . He was capable of penetrating insights and often ventured his ideas, but his style was to concentrate on clear and concise judgements about actions to accomplish the task at hand.

"His instinct for organization brought a calming influence to the inevitable calamity of fund-raising drives. His fine mind was always tempered with good common sense, an appreciation for the impact of decisions on subordinates, and a keen sense of humor."

General Lampert was born in Washington, D.C., and was commissioned in the Artillery (soon transferring to the Corps of Engineers) following graduation from the U.S. Military Academy in 1936. Before and during World War II he held various engineering assignments in the U.S., the South Pacific, and Japan.

Then came a series of increasingly important posts in the application of new technology to military needs in the Manhattan Project, the Armed Forces Special Weapons Project, and the Joint Army-A.E.C. Nuclear Power Program, of which he was Officer-in-Charge.

Following service in Viet Nam as Brigadier General, Mr. Lampert held major posts in the U.S. military establishment: Director of Military Construction from 1961 to 1963, Superintendent of the U.S. Military Academy from 1963 to 1966, Deputy Assistant Secretary of Defense for Manpower from 1966 to 1969, and U.S. High Commissioner of the Ryukyu Islands from 1969 to 1972. In this last post he was head of the civil government of those islands, charged with encouraging the development of an effective, responsible, and democratic government for them and finally with a major role in their transfer to Japan. It was during this period that General Lampert became

immensely respected in Japan; and this, in turn, led him to achieve closer relationships between M.I.T. and many Japanese industries after he joined the Institute's senior administration in 1972.

General Lampert held many military distinctions and at the time of his death was President of the Association of Graduates (the alumni organization) of the U.S. Military Academy.

"General Lampert's lifetime of service in the cause of national defense, his statesmanship in building international friendship, and his dedication in advancing education and research at M.I.T. have enlivened and enriched our national life," Mr. Johnson wrote members of the Corporation.

R. Lowell

Ralph Lowell, 1891-1978: 29 Years on the M.I.T. Corporation

Ralph Lowell, a leader in Boston and its financial and philanthropic institutions who had been a member of the M.I.T. Corporation for 29 years, died on May 15; he was 87.

Mr. Lowell was first elected a Special Term Member of the Corporation in 1949; five years later he became a Life Member, and he was made Life Member Emeritus in 1962; at the time of his death he was the eldest member of the Corporation.

Mr. Lowell is also remembered for two other associations with M.I.T.:

Since 1945 he had been the sole Trustee of the Lowell Institute, supporting the Lowell Institute School established at M.I.T. to provide evening instruction in technical subjects. Bruce D. Wedlock, '56, Director of the School, says Mr. Lowell was "a significant and perceptive leader . . . eager to make certain the School kept abreast of (technological) change and truly reflected the vocational needs of its students"

It was also through the Lowell Institute that Mr. Lowell had a key role in initiating educational broadcasting in Boston, establishing in the Lowell Institute Cooperative Broadcasting Council a consortium of Boston educational institutions (including M.I.T.) to guide and support radio station WGBH. Now an increasing number of Boston schools and cultural institutions, working through the Council, help make WGBH-TV (Channel 2) one of the leading educational television stations in the U.S.

Deceased

Perkins Boynton, '01; May 30, 1975; 228 Sumner St., Clarksburg, W. Va.
Ambrose M. Merrill, '04; October 2, 1977; 349 77th St., Brooklyn, N.Y.
Augustus S. Boynton, '06; May 30, 1978; c/o Folk, 68 Giddings Ave., Windsor, Conn.
Martin J. Foley, '06; December 22, 1977; 351 Nahant Rd., Nahant, Mass.
Freeman M. Scales, '06; June 3, 1975; 2 Mary Jane Ln., Newport, R.I.
John Evans, '07; April 23, 1978; 38 Polo Club Cir., Denver, Colo.
Charles L. Lufkin, '08; February 25, 1978; c/o Monoliais Theodore, 3476 City National Bank Bldg., Detroit, Mich.
J. Worth Maxwell, '08; May 22, 1978; 2734 Silver Ave., El Paso, Tex.
William D. Milne, '08; November 29, 1977; P.O. Box 221, Carlisle, Mass.
Max S. Rohde, '08; April 16, 1973; 2 Horatio St., Apt. 8A, New York, N.Y.
Harry Webb, '08; February, 1973.
Louis P. Dautremont, '10; September 3, 1977; 4002 New London Rd., Duluth, Minn.
Harold F. Shaw, '11; March 30, 1978; 48 Grove Ave., #1, Leominster, Mass.
Osborne H. Shenstone, '11; January 28, 1978; c/o J. C. Shenstone, 225 Harraw Cir., Birmingham, Mich.
Charles W. Webber, '12; March 29, 1978; 386 Central St., Acton, Mass.
Halsey Elwell, '13; May 14, 1978; Rural Rt. #2, Bemidji, Minn.
Vernon G. Kay, '13; August 10, 1977; 67 M. Rockledge Rd., Hartsdale, N.Y.
John S. Little, '15; May 5, 1978; Bay Village of Sarasota #701, 8400 Vamo Rd., Sarasota, Fla.
Harold Worthington, '15; March 8, 1978; P.O. Box 158, Northport, N.Y.
D. K. Este Fisher, Jr., '16; January 27, 1978; 3908 No. Charles St., Baltimore, Md.
Percy C. Peters, '16; April 21, 1977; Green Grove Nursing Home, 134 N. St., North Reading, Mass.
Wendell B. Ford, '17; June 3, 1978; 20 E. Exchange St., St. Paul, Minn.
Clifford D. Winton, '17; March 13, 1978; Gouldsboro, Maine.
Harold V. Atwell, '18; June 8, 1978; 36 H St. Paradise Bay Trailer Pk., Bradenton, Fla.
Julian C. Howe, '18; June 5, 1978; 6 Hundreds Cir., Wellesley Hills, Mass.
Henry Pinkerton, '18; April 29, 1978; 1402 So. Grand Blvd., St. Louis, Mo.
Wingate Rollins, '18; March 9, 1978; 196 School St., Milton Village, Mass.
R. Robinson Rowe, '18; May 4, 1978; 2701 Third Ave., Sacramento, Calif.
Arthur R. Ford, '19; April 15, 1978; 212 Rodney Rd., Ridley Park, Penn.
George C. McCarten, '19; October 15, 1974; 14 Pleasant St., Lancaster, N.H.
Eugene R. Smoley, '19; May 3, 1978; 50 East Rd., #11E, Delray Beach, Fla.
Earl P. Stevenson, '19; June 28, 1978; 282 Beacon St., Boston, Mass.
Ernst F. D. Von Voss, '19; December 17, 1976; Box 174-B Rt. 5, Brenham, Tex.
John W. Logan, Jr., '20; May 13, 1978; 800 Preston St., Bedford, Penn.
Eugene L. Harlin, '21; September 20, 1977; P.O. Box 617, West Plains, Mo.
Robert E. Manley, '21; January 29, 1977.
John F. Austin, Jr., '22; April 24, 1978; 11448 Dumbarton, Dallas, Tex.
Charles H. Bradley, '22; May 31, 1976; 108 Levert Ave., Mobile, Ala.
Harold S. Bronson, '22; January 19, 1978; 62 Stewart Dr., Rochester, N.Y.
Shepard Dudley, '22; March 28, 1978; 17 Inwood Rd., Essex Fells, N.J.
William J. Grady, '22; October 30, 1977; 26 N. Crescent, Maplewood, N.J.
John J. Lane, '22; July 29, 1974; 4701 Willard Ave., Chevy Chase, Md.
Albert P. Powell, '22; October 9, 1977; Paradise Bay Trailer Pk., Box 27; Second St., Bradenton, Fla.
Thomas D. Tyne, '22; April 11, 1978; 200 Hope Rd., Tinton Falls, N.J.
Lowell I. Holmes, Sr., '23; April 21, 1978; 637 40th St., Sarasota, Fla.
William F. Perkins, '23; July 7, 1975; c/o George Nugent R.F.D. #1, Durham, N.H.
John A. Robbins, '23; January 6, 1978; 146 Cheswold Valley Rd., Haverford, Penn.
F. Robert Robinson, '23; November 25, 1974; Hardwell Hotel, Rutland, Vt.
R. Winston Rouse, '23; June 2, 1978; 403 Palm Way, Tavares, Fla.
Charles O. Duevel, '24; June 22, 1977; Seaplace, 204 Gulf of Mexico Dr., #213, Sarasota, Fla.
Andrew G. Aylies, '25; December 23, 1975; 19503 Morley Ave., Cleveland, Ohio.
James L. Clifford, '25; April 7, 1978; Apt. 6A, 25 Claremont Ave., New York, N.Y.
William D. Ketchum, '25; April 15, 1977; 3006 Sharpsburg Cir., Birmingham, Ala.
Douglas E. Steinman, '25; 1974; 3755 Long Ave., Beaumont, Tex.
Raymond A. Freeman, '26; February 10, 1978; 5 Willard Pl., Hudson, N.Y.
William L. Freeman, '26; October 5, 1976; 3905 N.W. Clarence Cir., Corvallis, Ore.
Harry J. Hemphill, '26; June 28, 1973; 274 Kings Highway E., Haddonfield, N.J.
Wendell C. McClure, '26; October 15, 1975; 8560 Niles Center Rd., Skokie, Ill.
Bart Prioli, '26; October, 1977; 87 Woods Ave., Somerville, Mass.
Stanley M. Thomson, '26; January 19, 1978; 29 Castle Frank Cr., Toronto, Ontario, Canada.
Gordon I. McNeil, '27; February 28, 1978; 330 E. Perry St., Port Clinton, Ohio.
Louis F. Pike, '27; March 30, 1978; 220 Ansonia Rd., Woodbridge, Conn.
Gerald S. Brickett, '28; May 7, 1978; 41 N. Court St., Westminster, Md.
Wilbur F. Broun, '28; May 31, 1977; Box 92, Coolin, Idaho.
George Sabol, '28; September 12, 1977; 329 Mitchell Ave., Clairton, Penn.
Robert E. Frierson, '29; May 13, 1977; 3636 Taliluna Ave., Apt. 230, Knoxville, Tenn.
Paul H. Gill, '29; May 31, 1978; 4 Overlook St., Whitinsville, Mass.
Carl W. Harris, '29; April 30, 1978; 700 Dream Island Rd., Longboat Key, Fla.
Howard B. Hutchinson, '29; May 13, 1978;

805 Devonshire Way, Sunnyvale, Calif.

M. Edgar Powley, Jr., '29; March 30, 1978; c/o Wallingford, 11 Austin Dr., Sudbury, Mass.

Rudolph D. Wisbrun, '29; February 18, 1978; 714 Univ Ave., El Paso, Tex.

Albert G. Nault, '30; April 14, 1975; 48 Hamilton St., Worcester, Mass.

Norman J. Smith, '30; June 26, 1976; 7719 14th S.W., Seattle, Wash.

Nicholas J. Fisch, '31; April 17, 1975; 166 79 22nd Ave., Flushing, N.Y.

Samuel Garre, Jr., '31; April 26, 1978; 405 Cotswold Ln., Wynnewood, Penn.

William H. Duffy, '32; March 30, 1978; 236 Summer St., Weymouth, Mass.

John A. Hagen, '32; June, 1974; 11463 Lockwood Dr., Silver Spring, Md.

Robert M. Jackson, '32; December, 1977; Apt. 12 E, One Westgate, 1111 Gulfstream Dr., Sarasota, Fla.

J. Lincoln Moore, '32; March, 1977; 208 W. Main St., Lake City, S.C.

Ebed L. Ripley, '32; April 1, 1978; Box 206 — R.F.D. #1, Brattleboro, Vt.

Francis T. Hall, '33; June 21, 1978; Box 144, Dennis, Mass.

Benjamin C. Hiatt, '33; May 1, 1978; 9 St. Andrews Dr., Tuckerton, N.J.

Edward S. Quinlan, '33; March 22, 1978; 1755 Telshor Blvd. #34, Las Cruces, N. Mex.

Werner P. Rose, '33; March 21, 1977; 684 West Shore Trail, Sparta, N.J.

Richard H. Shepp, '33; March 16, 1977; P.O. Box 725, Kilmarnock, Va.

Joseph Daleda, '34; January 27, 1977; Texaco Dev. Corp., 135 E. 42nd St., New York, N.Y.

Rene G. DuBois, '34; October, 1976; 1977 Gulf Shore Blvd. N. #605, Naples, Fla.

George E. Fickett, '34; May 25, 1978; 411 Oriental Poppy Dr., Venice, Fla.

Harry W. Fox, '34; May 26, 1978; Apt. 844, 1311 Delaware Ave. S.W., Washington, D.C.

Arthur S. Hamilton, Jr., '35; September 23, 1977; 340 Panorama Trail, Rochester, N.Y.

Henry P. Parker, '35; November 15, 1977; c/o T. Sprague, Danforth, Maine.

John U. Bete, '36; May 12, 1978; 2 Main St., Marion, Mass.

John J. C. Coffin, '36; April 14, 1978; Jewell St., Amesbury, Mass.

Walter S. Denham, '39; May 29, 1977; 4735 Rolando Blvd., San Diego, Calif.

Thomas D. Kroner, '40; November 13, 1976; 38 Pickwick Rd., Marblehead, Mass.

John K. Ross, '40; January 28, 1978; 1270 Regent Rd., Apt. 12, Montreal, Canada.

Edgar W. Burns, '42; December, 1976; South Ferry Rd., Shelter Island, N.Y.

Marshall R. Ross, '44; March 23, 1976; Apt. 10B, 407 Lincoln Rd., Miami Beach, Fla.

Edward F. Byers, '46; August 26, 1977; 500 Springvale Rd., Great Falls, Va.

Kenneth K. Klingensmith, '47; June 6, 1978; 26 Margo Ct., Cromwell, Conn.

Ellis L. Barron, '48; May 21, 1978; 8703 Bellwood Rd., Bethesda, Md.

Joe W. Thornbury, '49; June 22, 1976; P.O. Box 4382, Fort Pierce, Fla.

Robert J. Vidal, '49; May 28, 1978; 4920 Cliffside Dr., Clarence, N.Y.

Stanley E. Ellison, '50; August, 1977; 5113 Henderson Rd., Washington, D.C.

Otto F. Meyer, Jr., '50; November 28, 1977; 3641 Bonita Verde Dr., Bonita, Calif.

Arthur R. Blackwell, '51; May 11, 1978; 1314 Towlston Rd., Vienna, Va.

John C. Murkland, '54; April 24, 1978; 53 Round Hill Rd., Greenwich, Conn.

John J. Mahoney, '58; October 26, 1977; 125 Latch Dr., San Antonio, Tex.

Vladimir P. Benishin, '59; January 24, 1976; 606 N. George St., Rome, N.Y.

John H. Eide, '59; August 3, 1977; 30 Gregory Ln., Warren, N.J.

Jerome H. Marcus, '61; January 13, 1978; 135 East Olive St., Long Beach, N.Y.

Alan T. Hundert, '62; December 15, 1977; R.F.D. 1, Box 31, Fox Den Rd., Mount Kisco, N.Y.

Norman R. Cohler, '64; March 24, 1978; 906 Raintree Ct., San Jose, Calif.

Dino A. Egidio, '69; April 16, 1978; 200 Swanton St. #426, Winchester, Mass.

John Marshall II, '73; May 19, 1978; 58 Currier Pl., Cheshire, Conn.

Mark S. Hannig, '75; April 15, 1978; 106 Allendale Pl., Terre Haute, Ind.

Timothy C. Livengood, '75; April 29, 1978; 1503 Locust Ln., Atlantic, Iowa.

Emory A. Brown, '77; August 24, 1977; Council for Airport Opport., Two World Trade Center, Suite 2228, New York, N.Y.

perts in Chinese regional cooking. This change has even been recognized by food processors who produce for the mass market products based on Chinese themes and containing Oriental foods including bok choy, water chestnuts and bean curd.

Predicting Food Preferences

A rise in income leads to an increase in the consumption of more expensive food products. An expenditure elasticity of demand can be calculated to estimate what people purchase as their income increases. Products with high elasticity are theoretically more desirable than those with lower or negative elasticities. These elasticities have been computed for several communities and several products. In general, the pattern of demand parallels the trends in food consumption patterns shown. However, the magnitudes of the function are generally higher in rural as compared to urban samples. The relationship between income and demand leads us to believe that elasticities should fall as income increases, and that the desire for a product decreases as the product is acquired. It has been argued then that this difference in elasticities between rural and urban communities may be a function of the fact that income is higher in city than country.

To test this hypothesis, elasticities were calculated for India at mean rural and urban incomes for demands in both areas (*above*). While some of the difference could be accounted for by the difference in income, the more interesting fact was that, given the same income level, the elasticities in the rural area are consistently *lower* than those in the city. The only exceptions to this trend are those for sugar and cereal. The reason for this difference may be attributed in part to the higher cost of food in the city, particularly processed or imported items. In general, however, these data strongly suggest a fundamental shift in demand for certain foods as a result of migration to urban centers. Such shifts have significance in predicting future food needs, particularly in terms of distributing limited resources into different areas of food production. The increasing urban population predicts an increasing demand for meat, fish, eggs, milk, fats and processed foods while predicting a decrease in need for cereal grains for direct human use.

The food groups projected for the most rapid rise in demand are those for which the least efficient use of resources can be made. The passage of cereal protein and energy through animals results in an increase in nutritive quality, but a considerable loss in efficiency of utilization. If conventional agriculture cannot increase its productivity to match the decrease in utilization efficiency, and if the costs are too high of modifying cereal grains or the products of non-agricultural food production to permit high acceptability, then some attempt must be made to direct these changes in food habits resulting from urban migration towards more reasonable goals. To do this, a much better understanding of the forces involved in this process must be developed.

Demand elasticity computed by location and income level

	Rural average	Urban average	Rural high	Urban low
Cereal	0.46	0.21	0.39	0.23
Sugar	1.05	0.66	0.73	0.91
Meat, eggs, and fish	0.75	0.85	0.57	1.32
Dairy products	1.24	0.96	0.81	1.62
Fats and oils	0.78	0.62	0.59	0.84
Other	0.88	0.88	0.64	1.40

The elasticities of demand for various food groups in rural and urban India can be calculated and used to estimate what people buy as their income increases. The more desirable items are those with high elasticities. In general, the magnitudes of the function are higher in rural as compared to urban samples. To test the hypothesis that the difference in rural and urban elasticities may merely be a function of the fact that city income is higher, the elasticities were recalculated at the average rural (urban/low) and urban (rural/high) incomes. The numbers can be read to show that a fundamental shift in the demand for certain foods results with urban migration: with the exception of sugar and cereal, a comparison of the elasticity of demand for foods by urban and rural people of like income shows rural elasticities to be consistently *lower* than for those in the cities. (These data were adapted from deNigris, *F.A.O. Monthly Bulletin of Agricultural Economics and Statistics*, 22:1, 1973.)

K. Guggenheim and N. Kaufman studied the pressures resulting in a change of food habits of a variety of immigrant groups in Israel. They have suggested several areas of investigation:

☐ First, it is clear that changes do occur and that they occur with great rapidity. The inertia and conservatism of food habits appear to be significantly less rigid in relation to the pressures for changing these habits. In general, ethnic habits are maintained mostly in terms of cooking styles and the use of herbs, spices and condiments. Foods consumed, however, are expanded to include the components of typical urban diets. These responses also have been reported for new immigrant families in Canada where the dietary changes were also directed towards a more urban pattern with retention of traditional flavor additions and cooking styles.

□ Second, the principle causes of these changes appear to be increased availability of new foods, better communication (such as advertising) and the pressures of status transmitted largely through the children. While Drs. Guggenheim and Kaufmann argue that education of the children played an important role, the facts do not support this: the changes noted included increases in nutritional stress foods as well as the so-called protective foods. It is more likely that these changes occurred as a result of the desire of the children to conform to the mores of their peers at school rather than a desire to reach a health-related long-term goal.

If these observations are correct, the critical point for intervention is the market, the radio or television, and generally in the schools — not as an educational program but as a traditional advertising campaign based on a basic desire to attain status and the satisfaction of other emotional needs. In other words, it requires the input of the food industry directed not only towards the role of products to provide profit but also towards the production of products of high nutritional quality. The food industry should be encouraged to continue traditional marketing strategies and, in fact, to expand them. However, they must also be made to assure high nutritional quality of the foods they huckster.

Thus far, we have discussed changes occurring in the developing world or at best the newly developed world. Are similar events occurring in the more affluent segments of world society? Are the changes predicted on p. 41 correct in that increasing income must result in continual reduction in dietary quality and continual deterioration in health?

Balancing Between Nutrition and Enjoyment

With the exception of the period of the Second World War, there had been a continual movement of dietary patterns towards the ultimate urban pattern in the U.S. Large increases in fat, sugar, and meat consumption were noted, as were increases in the consumption of fruits and vegetables. Cereal intake dropped sharply. Interestingly, total caloric intake appears to drop since 1910 with the greatest change seen in the period after 1950. Thus it appeared that nearly all the changes predicted by rising income and increasing urbanization were occurring. Health statistics appeared to confirm this pattern, showing increasing obesity (more than 20 per cent of the U.S. adult population), cardiovascular disease, stroke and hypertension, all true until 1970. At that time, there occurred precipitous drops in nearly all categories. In the last year, for example, decreases of 1 per cent to 4 per cent in several food groups have been observed. Recent health statistics confirm this finding reporting a drop in all mortality categories except suicide. More amazing is the fact that these changes are largely the result of effects in higher socioeconomic groups.

This suggests that the magnitude of the change in these groups is much greater than the overall statistic implies. The fact that the basic relationship still holds is suggested by the fact that, in the U.S., the highest incidence of obesity is in black women and that infantile obesity is increasing in the lower economic groups. This results, I believe, from the fact that these groups have moved up the economic scale into the area in which the diseases of affluence predominate. It also suggests that the trends cannot be simply extrapolated but must include a drop at higher income levels in caloric intake and a consequent improvement in nutritional quality of the diet. The reasons for this shift are unknown, but I would submit that it may be the first response to nutrition education. It may be that long-term consideration of future health becomes of importance only when income (and time at income level) reach a stage at which most desires have been or can be satisfied and new "cosmic consciousness" can now play a role. This point is suggested by the arrow in the figure on p. 41. From a practical point of view, it suggests that efforts in nutrition education that promise future benefits in health and longevity in return for present restraint are not worthwhile at low or moderate income levels. It also suggests that appeals to the more fundamental ego components of food choices such as status and cuisine may be more appropriate for these groups if changes in food selection patterns are to be desired.

The future of human society is to a great extent dependent upon the ability of political structures to supply food appropriate in amount and in variety to their population. While "Bread and Circuses" were the currency of the classical Roman politician, I would argue that bread had by far a greater value. In today's world, all human beings have the right to be well fed. No greater goal can be subscribed to by any government. Yet, to accomplish this task rapid and reasonably, accurate estimates of future food needs are required. I would suggest that such estimates may be possible if an appropriate dynamic model can be constructed which accounts for the several factors involved. Of these, I would submit that population change in combination with knowledge of urban migration patterns and their influence on food selection may prove to provide a significant portion of the necessary data. In any case, I would also suggest that research in this area is an essential prerequisite to its solution. Data for the construction of the model do not exist nor are they accurate.

The solution of the critical problem of societies' food needs will require the dedicated efforts of several selfish

groups who in their own self-interest must provide for the "future unto generation." The collaboration of nutritionist, anthropologist, sociologist, food technologist, economist, planner, politician, statesman, and perhaps, most of all, the food industry is essential and indeed mandatory for the future of mankind. Can we not now agree to do so?

Suggested Readings

Altschul, A. A., "Protein Food Technologies and The Politics of Food," *New Protein Foods,* A. Altschul, ed., Vol. IA, p. 1, New York: Academic Press, 1974.

Altschul, A. A., and Grommet, J. K., "The American Diet: Food Choices and Stress Foods," 1977. (In preparation)

Brown, L. R., "New Protein Foods," *PAG Bull.,* Vol. 2, p. 75, New York: P.A.G., U.N., Syst., U.N., 1972.

deNigris, M., "The Impact of Urbanization on Food Demand," *FAO Monthly Bull. of Agric. Econ. and Statis.,* Vol. 22, p. 1, 1973.

Drummond, J. C. and Wilbraham, A., *The Englishman's Food: A History of Five Centuries of English Diet,* London, p. 29, 1964.

Epstein, A. N., "Alimentary Canal," *Handbook of Physiology,* C. F. Code, ed., Washington, D.C., p. 197, 1967.

Fernandez, N. A., "Nutrition in Puerto Rico," *Cancer Res.,* Vol. 35, p. 3272, 1975.

Flores, M., "Dietary Studies for Assessment of Nutritional Status of Populations in Nonmodernized Societies," *Amer. J. Clin. Nutr.,* Vol. 11, p. 344, 1962.

vonFoerester, H., Mora, P. M., and Amiot, L. W., "Doomsday, Friday, 13 Nov. AD 2026," *Science,* Vol. 132, p. 1291, 1960.

Ganzin, M., Perisse, J., and Francois, P., "Need for Food and Nutrition Policies," Man, Food and Nutrition, p. 275, M. Rechcigl, ed., Cleveland, Ohio: CRC Press, 1973.

Guggenheim, K., and Kaufmann, N.A., "Nutritional Health in a Changing Society — Studies From Israel," *World Rev. of Nutr. and Diet,* Bourne, G. H., ed., Vol. 24, p. 217, New York: S. Karger, 1976.

INCAP, "Evaluacion Nutricional de la Publacion de Centro America y Panama," 1970.

Leninger, M. M.,"Some Cross-cultural Universal and Non-universal Functions, Beliefs and Practices of Food," Dimensions of Nutrition, p. 152, J. Dupont, ed., Boulder, Colo.: Colo. Assoc. Univ. Press, 1970.

Lowenberg, M. E., "Sociocultural Basis of Food Habits," *Food Technol.,* Vol. 24, p. 27, 1970.

Marr, J. W., "Individual Dietary Surveys: Purposes and Methods," *World Rev. Nutrition & Dietetics* Bourne, G. H., ed., Volume 13, p. 105, New York: S. Karger, 1971.

McKenzie, J. C., "Past Dietary Trends as an Aid to Prediction," *Our Changing Fare,* p. 135, Barker, McKenzie & Yudkin, eds., London: MacGibbon & Kee, 1966.

Mead, M., "Malnutrition and Food Habits," *Report of an International and Interprofessional Conference,* Burgess & Dean, eds., London: Tavistock, 1962.

Miller, S. A., "Additives in Our Food Supply," *Food and Nutrition in Health and Disease,* Moss & Mayer, eds. Annals New York Acad. Sci., (in press), 1977.

Milner, M., Scrimshaw, N. S., and Wang, D. I. C., *Protein Resources and Technology: Status & Research Needs,* Westport, Conn.: Avi Press, 1977.

Niehoff, A., "Changing Food Habits,"*J. Nutr. Educ.,* Summer, p. 10, 1969.

Pekkarinen, M., "Methodology in the Collection of Food Consumption Data," *World Review of Nutrition & Dietetics,* Bourne, G. H., ed., Vol. 12, p. 145, New York: S. Karger, 1970.

Perisse, J., Sizaret, F. and Francois, P., "The Effect of Income on the Structure of Diet," *FAO Nutr. Newsletter,* Vol. 7, p. 1, 1969.

Schmeck, H. M., *New York Times,* p. 11, Friday, April 1, 1977.

Toronto Nutrition Committee, "Food Customs of New Canadians," Toronto, Canada, 1967.

Tannahill, R., *Food in History,* New York: Stein & Day, 1973.

U.N. Monthly Bull. of Statistics, Vol. 25, p. 11, 1971.

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Changing Economic Patterns

Jay W. Forrester

A half-century after 1929, are we now at the brink of another "great depression," or perhaps at the end of an age of technology? Can the power of the computer-based System Dynamics National Model help us foresee how to avoid a damaging contraction of our present economic capacity?

The human intellect, even with all the economic theory and conventional mathematical analysis which it has devised, is unable to cope with the complexity inherent in modern socio-economic behavior. There are too many pieces in the economic puzzle.

The new economic pressures are mutually reinforcing. The emerging patterns are locked into one another like pieces of a jig-saw puzzle. Productivity is related to capital investment; environmental pressures arise from the growth of population and industrial activity; energy questions are connected to the falling value of our dollar. Symptoms appear in one economic sector from causes that arise in another. Each part changes through time and sets up new situations to which other parts respond. More and more, we realize that everything is connected to everything else. But the multiple interconnections are not easy to understand. Intuition and political debate are proving to be inadequate tools for managing economic change.

In the last few years it has become possible to bring economic behavior into the laboratory where its many interconnected causes and effects can be studied in detail and traced back to their sources in underlying business and government structures and policies *(see "Counterintuitive Behavior of Social Systems," by Jay W. Forrester, January, 1971).* Handling such a rich representation of economic reality has become practical with modern computers and simulation models. This representation of economic behavior in a laboratory makes possible a comprehensive role-playing process in which critical economic and political factors — policies affecting hundreds of points in the economic system — can be described and interrelated with one another. Alternative policies can then be tried in the model to see if economic behavior is improved.

For the last six years we have been constructing such a laboratory representation of the economy in the form of the System Dynamics National Model which is built up from policies followed in major sectors of an industrial economy. The Model connects sectors through flows of people, information, money, prices, and goods. It represents the details of economic activity at the level of the internal structure of corporations. It contains 15 industrial sectors, such as consumer durables, capital equipment, energy, agriculture, and building construction. Each industrial sector of the Model is constructed to represent a typical business firm in that sector of the economy. The Model represents production processes in comprehensive detail, adjusting changes in input factors for production on the basis of many aspects of the economic environment — including inventories, prices, costs, order backlogs, growth rate, marginal productivity, liquidity, profitability, return on investment, and regulatory restraints. Each production sector of the Model contains a full accounting system that handles accounts payable and receivable, generates a full balance sheet and profit-and-loss statement, pays taxes, and computes indices of financial performance. The market clearing function, which balances supply and demand, responds not only to price but also availability of the product; this availability, or delivery delay, simulates market behavior in the real economy, where many prices change slowly and supply and demand are partially balanced by allocation and delays in filling order backlogs.

In similar detail, the Model contains a labor mobility network for the movement of people between sectors, a banking system, the Federal Reserve, household-consumption sectors, a government sector, and a demographic sector. The Model is a translation into computer language of the knowledge people have about organizational structure and operating policies surrounding their daily activities.

Such a model is designed to be a role-playing replica of the real economy. It should behave like the real economy, generating the growth, fluctuations, shifts in population between sectors, inflation, unemployment, and other

phenomena in the real world. Tested by the criteria of exhibiting behavior like that of the actual economy, the National Model is making solid contact with economic reality. The Model demonstrates its realism by generating the same kinds of behavior that are so puzzling in the national economy. For example, the Model exhibits the three major fluctuating modes of behavior that have been recognized and discussed in the economic literature — three-to-seven-year business cycles, intermediate-term (15 to 25 years) investment (or Kuznets) cycles, and long-wave or Kondratieff cycles spanning some 45 to 60 years.

The advantage of a model in the laboratory is to permit the conducting of experiments. By changing policies that govern behavior, one can isolate the true causes of economic difficulty. One can alter policies in a model to anticipate how similar changes would affect the actual economic system.

From using the National Model to examine causes of U.S. economic behavior, we are convinced that short-term (three-to-seven-year) business-cycle behavior arises primarily from management of inventories, backlogs, and employment (*see "Modeling Cycles in the National Economy," by Nathaniel J. Mass, March/April, 1976*).

Thus our work supports those theories that give a central role in business cycles to the interaction between employment and inventories, in contrast to the theory that now dominates government policymaking, assigning an essential role to fluctuation in capital investment. Although many government policies attempt to influence cyclical economic behavior by affecting capital investment, we are coming to believe that manipulating interest rates, credit availability, and investment tax incentives can have little effect upon short-term business cycles. The times required for capital construction and depreciation are too long to fit within the short time span of a business cycle. Two or three years may elapse as managers decide on new production facilties, design may require a year or more, construction another year or two, and then capital equipment lasts for ten to 40 years. Such long time intervals are not compatible with a business cycle that runs its course in some four years.

Two Capital-Investment Cycles

Although capital investment does not appear to have a central role in short-term business-cycle behavior, variations in capital investment are directly involved in the two longer cycles of economic fluctuation — the 15-to-25-year Kuznets cycles and the 45-to-60-year long wave. Both of the longer cycles are consistent with the time intervals involved in procuring and using capital plant.

Our work shows that the intermediate Kuznets cycle involves policies in the consumer durables (and probably agriculture) sectors for ordering capital equipment. A comparison is in order here. The short-term business cycle arises from interaction between the market and the durables sectors activated by employment policies in the durables sectors that attempt to manage backlogs and inventories of durables. In similar fashion, the intermediate Kuznets cycle arises from interaction between the durables sectors and the capital sectors through employment policies in the capital sectors that attempt to manage backlogs and inventories of capital equipment. The Kuznets cycle is apt to appear as "shoulders" or an accentuated peaking of the long wave. A downturn in the Kuznets cycle could account for the greater severity of the 1958 recession, the accentuated capital-investment peak around 1971, and the plateau that is typically described as following a peak in the long wave. But the Kuznets cycle does not appear to be nearly as significant to economic behavior as the long wave.

I am coming to believe that the long wave, which seems also to be related to capital investment, is more important in explaining economic behavior than either the business cycle or the Kuznets cycle. Although it has been given little attention in the economic literature, the long wave, also known as the Kondratieff cycle (named after a Russian economist who during the 1920s studied the history of long-term economic fluctuation in the Western industrial economies), probably explains why economic trends are now no longer serving as a guide to the future. The long wave manifests itself as a massive expansion of the capital sectors followed by a relatively rapid collapse in their output. It is usually described as a peak of economic activity followed by a ten-year plateau, then a drop into a depression period for about a decade, and a long climb over some 30 years to the next peak. Long-wave behavior seems to account for the great depressions of the 1830s, 1890s, and 1930s, and it may be of critical importance in explaining our present economic situation. Forces arising from the long wave seem to explain many present economic cross-currents, raising the spectre of another depression period in the 1980s.

Our work on the long wave is typical of new insights that can come from analysis using a system dynamics model. We started with no expectation that the National Model should generate long-wave behavior. In fact, I was unaware of the scant literature on the long wave while we were initially formulating the Model. But when we assembled a consumer durables sector with a sector that produces capital equipment, we found that the Model exhibited violent fluctuation in the capital sector with about 50 years between peaks of capital output.

When such unexpected behavior is encountered in a

model, the prudent investigator first questions the structure and plausibility of the model; anomalous behavior often points to dubious assumptions in model structure. However, as the quality of a model improves, unanticipated model behavior is more likely to suggest new insights about actual economic behavior. After we analyzed the reasons for the 50-year mode of behavior in the National Model, we concluded that the underlying assumptions still seemed reasonable. It was then that the literature on the Kondratieff cycle was brought into the investigation.

That literature turns out to be confused and contradictory. A 50-year fluctuation has been observed in many economic variables, but there has been no acceptable theory explaining why a long wave should occur. We now think that the National Model provides a theory for the central process of the long wave and shows a unity between aspects of behavior that had previously seemed contradictory. For example, the observation that many economic time series do not show long-wave behavior has been given as an argument against existence of a long wave in the economy. But the same apparently contradictory facts are replicated in the National Model itself; the output of consumer goods remains almost constant even though capital sectors are experiencing major cycles of expansion and collapse.

Anatomy of a Long Wave

Long-wave behavior, as revealed in the National Model, seems to explain many things now happening in the economy. The economic conditions we are now experiencing are much like those the National Model exhibits at a peak of the long wave — a decline in capital investment, rising unemployment, a leveling out in labor productivity, falling return on investment, increasing amplitude of business cycles, and reduced innovation from maturing of the then-current wave of technological advance. Such conditions fit today's situation. Similar conditions last occurred in the 1920s at the time of a previous long-wave peak. Indeed, the process of collapse and revival of the economy produced by the long wave can best be traced by thinking back to the United States in the 1920s. Fifty years ago, prices had been rising. Interest rates were high. Investment opportunities had diminished. The railroads had been completed. New York was afflicted by excess office space. Land prices had been rising sharply. Heavy debts had been incurred, and the financial system was overextended.

Under economic stresses that reached a climax in the 1920s, previous trends faltered and reversed in the 1930s. The earlier pace of capital investment slowed. Overcapacity appeared in many sectors of the economy. Prices fell under the pressure of oversupply. Wages were driven down by falling profits and high unemployment. Defaults and bankruptcies cleared out the excess debt load. Expansion ceased because agriculture and consumer sectors had excess capacity, so the demand for construction and capital equipment collapsed. For 15 years the country coasted on the physical capital plant that had been accumulated before 1930.

But by the end of World War II, physical capital at all levels had been depleted. Consumers needed housing and durables. Industry needed factories and machines. Society needed school systems and highways. So a great rebuilding began. Labor was drawn from consumer sectors into capital sectors, thereby producing a tight labor supply and still more incentive for consumer sectors to become more capital-intensive. Demand for capital was self-reinforcing: in order to expand, capital sectors themselves required new capital plant, thus creating further demand on capital sectors. A long, powerful regenerative process drove expansion of the capital sectors.

Capital plant was rebuilt in a rather brief 20 years, during which time construction capacity in the capital sectors grew to become greater than would later be required to replace physical depreciation.

Once capital plant had been rebuilt, could the capital-construction process be slowed to a sustaining rate? Assume that an appropriate level of capital plant was reached in 1965, as indicated by the return on investment in new capital plant beginning to decline and business-cycle recessions starting to become progressively deeper. But the capital accumulation process did not stop in 1965, because tremendous momentum had been established. Capital investment had become stylish. Labor unions wanted to build more highways and public schools. Banks had loaned money successfully on earlier construction and sought new opportunities to make loans. The Federal Reserve had provided credit expansion in the 1950s and 1960s without producing inflation and assumed the process could continue. For a full decade from 1965 to 1975, physical capital was forced into the economy beyond the point where capital earned a high return. But such investment in the face of falling incentive cannot continue indefinitely. Eventually, an excess rate of capital construction saturates the need for more capital plant.

From the 1920s to the 1970s is a typical 50-year period in the long wave, ending with fully developed technologies and saturated capital markets. At both the start and finish of the 50-year period, opportunities had declined for attractive investment in the maturing technology of the times. In the 1920s the nation had completed its railroad system, and by the 1970s it has completed the inter-

state highway and air transport systems.

There seem to have been two other long-wave cycles in the history of the United States prior to 1920. People often question the idea that a long-wave economic mode could have persisted for nearly 200 years, in spite of the major changes that have occurred in society and technology. But the policies and structures that generate the long wave have changed very little. The long wave appears to depend on production methods that use capital equipment, on the life of capital equipment and buildings, on the slowness of the process of moving people from one part of the economy to another, and on how far ahead people plan and the length of their memories of past economic disasters — both of which are substantially determined by the length of a human lifetime. None of these factors which give rise to the long wave depends substantially on faster communications or details of technological change. The policies and industrial structure that generate the long-wave capital-construction cycle have changed very little since 1800.

Golden Age or Economic Disaster?

If we are now at a peak in the long wave, we face the possibility of another major depression in the future. Such a prospect is at first frightening and seems inevitably pessimistic until one pauses to examine the fundamental nature of an economic depression.

Depressions have been times of excess capacity in nearly every sector of the economy. They occur immediately after capital capacity has been fully rebuilt. When a peak in the long wave is reached, the economy is capable of producing more than it has ever produced before. More housing has already been constructed and is available. People who are no longer needed to rebuild capital plant could turn their attention to previously neglected contributions to the quality of life. At the end of the rebuilding phase, an industrial economy is in the best physical condition it has ever achieved. It should be a golden age, the time toward which we have been striving.

Instead, the end of rebuilding has always led into a depression, a time of economic disaster, with hunger, unemployment, and even social breakdown.

A depression is a time of severe imbalance within an economy. Too many people remain in declining sectors. Debt is too heavy, even as profits from which to pay back that debt decline. Falling prices and wages direct money flows in a way that prevents the harnessing of production capacity for the well-being of people.

Yet at the onset of a depression, ample production capacity exists to raise everyone's standard of living to new heights. For 30 years U.S. industry has been rebuilding capital plant, thus increasing the output per worker. Productivity is now higher than ever before, even if it is not continuing to increase as rapidly as in the past. But for any given style of technology, the amount of capital plant can reach a point of saturation. The national economic question is, what do we do after making the investment necessary for sustaining a high standard of living? How do we take advantage of the favorable position we have now achieved? We lose sight of the economic fact that the process of building the capital plant should not itself be the goal; the goal should be a high standard of living made possible by having the capital plant. Can we manage the debt load, the conflict between inflationary and deflationary forces, and the imbalanced distribution of excess labor in the capital sectors so that we can keep the end of rebuilding from turning into a depression?

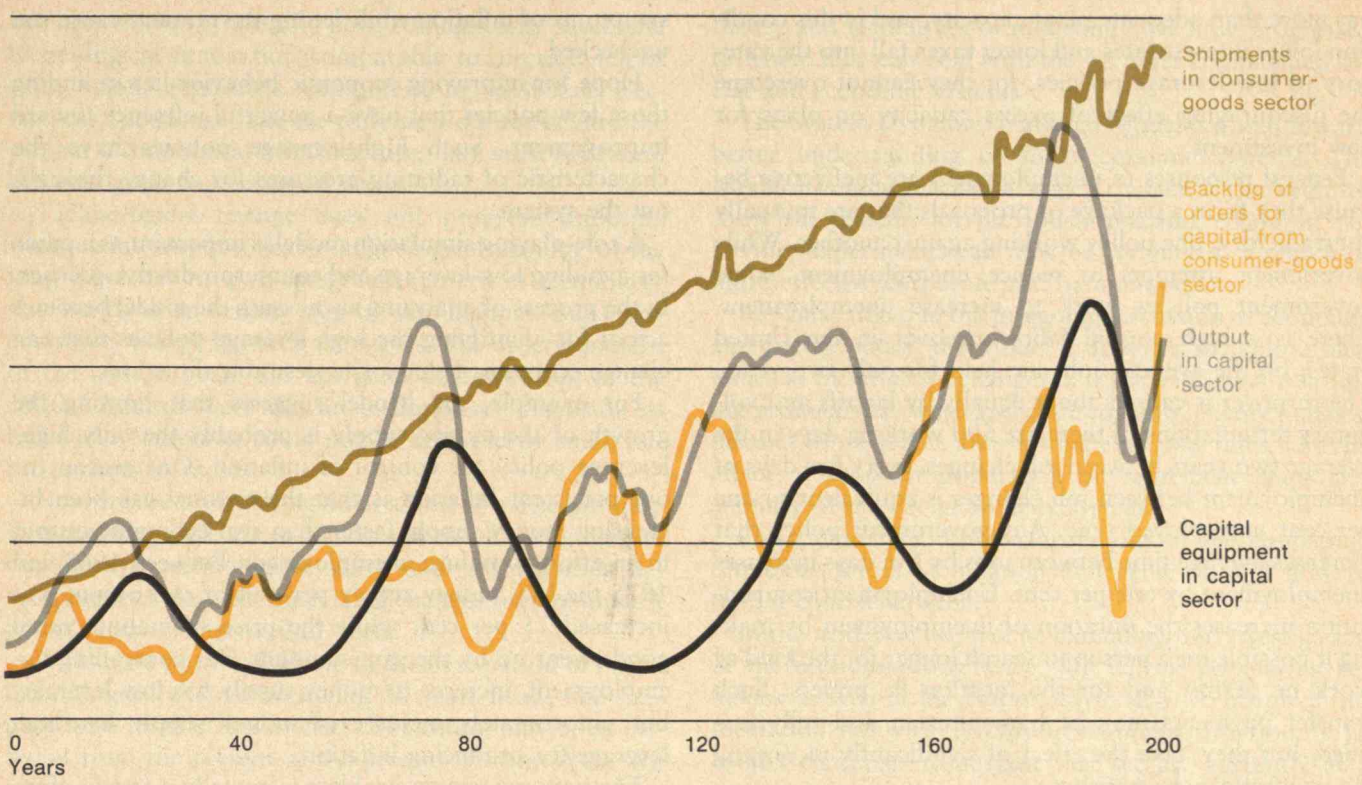
Historically, a depression following a long-wave peak has been deflationary. Prices, wages, and interest rates have fallen. But the 1980s could be different. Never before have there been such big government and such powerful inflationary forces. What can happen in a clash between inflation and deflation?

Managing the balance between inflation and deflation will become part of the question of managing debt. Historically, it has never been possible to pay back all the debt after a peak in the long wave. Deflation leads to erasing debt by defaults, thereby paying back only a fraction of the amounts due. Alternatively, inflation erases debt by depreciating the currency, thereby paying back only a fraction of the purchasing power originally borrowed. As we move out of a long-wave peak, can debt be repaid? If not, is there a better way to postpone repayment or write down debt than by using default or inflation? The balance between inflation and deflation and the question of how to extract ourselves from a heavy debt load are critical policy issues that need prompt resolution.

Low-Leverage Policies

One learns more from studying simulation models than merely how behavior like the long-wave fluctuation can occur. One also learns about general characteristics of social systems that have persistently frustrated managers and politicians. Our earlier modeling of corporations and cities has led us to identify several characteristics that I believe should guide thinking about real-life social systems.

We have found that a large proportion of the policies in a corporation or country have very little leverage for changing behavior. To make matters worse, the way people learn about systems usually causes them to focus on the very policies that are not capable of producing substantial change. Most managers have had the experience of facing a serious corporate problem, deciding on a



policy change to alleviate the problem, and discovering after several years of implementing the change that the problem still existed. They usually blame the persistence of the problem on some external circumstance, whereas the true explanation often lies in the capability of the corporate system to internally readjust in such a way as to compensate for the policy change. Indeed, social systems have a remarkable ability to counteract policy interventions.

We have seen such futile pursuit of ineffective policies in the last two decades in government efforts to solve the urban problem (*see "A Deeper Knowledge of Social Systems," by Jay W. Forrester, April, 1969*). In a similar way, dependence on low-leverage policies probably explains the present frustration in dealing with the economic situation.

Our work with the System Dynamics National Model suggests that monetary policy has low leverage in dealing with the present sources of unemployment. Pressure has been exerted by Congress and the President on the Federal Reserve to supply credit and to lower interest rates in the hope of reducing unemployment, on the assumption that lower interest rates will encourage investment and thereby create jobs in the capital sectors. But the present kind of unemployment is probably beyond the reach of monetary policy. The economy in most sectors already

Computer simulation showing the three principle modes of fluctuating behavior in the economy. This simulation derives from a partial assembly of the System Dynamics National Model; in this case, a consumer-goods sector orders capital equipment from a capital sector. The labor mobility network was not connected, so both sectors were able to procure labor as needed. The household-consumer sector was not yet installed and in its place was applied to the durables sector a rising demand with a few per cent of monthly-spaced randomness superimposed. The simulation extends through 200 years.

Shipments from the consumer-goods sector reflect the rising externally-supplied demand. But shipments also show a fluctuation typical of business cycles with peaks three to seven years apart. The business-cycle variation is triggered by the randomness in orders for consumer goods, but the characteristic interval between peaks results from interactions among the policies for managing inventories, backlogs, and employment.

The curve for the backlog of orders for capital shows those orders for capital equipment that have been placed by the consumer-goods sector but not yet filled by the capital sector. Although traces of short-term business cycles are visible, the dominant behavior shows a fluctuation of 15 to 25 years between peaks. Such a periodicity is typical of Kuznets cycles in the economy. It arises here from policies for ordering and producing capital equipment.

Output in the capital sector is the production rate for capital equipment. It shows traces of business and Kuznets cycles. But it shows a new behavior — the four conspicuous peaks spaced 45 to 60 years apart.

The curve for capital equipment in the capital sector shows almost pure long-wave behavior. The curve is for capital equipment in use by the capital sector for producing capital equipment. The long wave arises from a buildup and collapse of capital-producing sectors in the economy.

has more than adequate plant capacity, and in this condition lower interest rates and lower taxes fall into the category of low-leverage policies, for they cannot overcome the discouraging effect of excess capacity on plans for new investment.

Federal responses to unemployment are ineffective because they form a package of proposals that are mutually contradictory, one policy working against another. While government attempts to reduce unemployment, some government policies work to increase unemployment. There is a high normal labor turnover in the United States; on the average, jobs are held for only two years. The turnover is caused about equally by layoffs and voluntary terminations. If there are 500 working days in the average two years between job changes, every five days of unemployment between job changes is equivalent to one per cent unemployed time. Any government policy that increases average time between jobs by five days increases unemployment by one per cent. Unemployment compensation increases the duration of unemployment by making it possible for a person to search longer for the kind of work he desires and for the location he prefers. Such transfer payments may be humanitarian and fully justified, but they have the effect of significantly increasing the unemployment statistics.

This higher unemployment created partially by government programs has become the justification for policies that increase inflation — an example of how policies with low leverage on their intended target may produce harmful side effects in other areas.

Low-Leverage and High-Leverage Policies

Most of the proposed national energy policies fall into the low-leverage category. Many of the policies are designed to reduce energy consumption at the same time other policies maintain low energy prices that encourage consumption and discourage the development of new energy sources.

Present and proposed national policies will defeat most of our national objectives. Tax policies and energy policies are producing an unfavorable balance between the use of people and the use of energy (*see "Can We Save Energy By Taxing It?" By John F. Boshier, pp. 62-72*). We have a high tax on using people in the form of high income and Social Security taxes, yet at the same time government policies artificially hold down the price of energy. The result is strong financial pressures on employers to use energy instead of labor while the country develops an energy shortage and a labor surplus.

The country has so far also chosen low-leverage policies in attempting to manage inflation. Price controls, persuasion, and jawboning are efforts to suppress the symptoms of inflation while letting the primary cause run unchecked.

Hope for improving economic behavior lies in finding those few policies that have a powerful influence toward improvement. Such high-leverage policies have the characteristic of radiating pressures for change throughout the system.

A role-playing simulation model is important as a guide for avoiding low-leverage and counterproductive policies. In the process of analyzing such issues the model becomes a tool for identifying the high-leverage policies that can change economic behavior in desirable directions.

For example, the Model suggests that limiting the growth of the money supply is probably the only high-leverage policy for control of inflation. One reason for our persistent inflation is that the country has been increasing money supply faster than real economic output in an effort to reduce unemployment. Between 1965 and 1975 the U.S. money supply per unit of real output was increased 75 per cent while the price of manufactured goods went up by the same amount. For controlling unemployment, increase in money supply has low leverage, but unfortunately increase of money supply has high leverage for producing inflation.

The national energy problem is actually a tangle of interconnected issues. We need to conserve petroleum for more important uses than fuel. We need to encourage employment. We need to reduce imports to bolster the value of the dollar. For national security we need to reduce dependence on foreign energy sources. We need to encourage development of new energy sources that will belong to the new technology in the next investment phase of the long wave 20 years hence.

We need a high-leverage policy in the energy situation. To reverse the present drift into greater energy difficulties, we should invert present incentives. Instead of imposing a high tax on labor while holding down the price of energy, we should levy a high import tax on foreign energy. The revenue would be large enough to permit reducing income and Social Security taxes by a substantial fraction. Such an import tax should take the initiative for oil pricing away from O.P.E.C., increase employment, improve the balance of trade, and lead to future self-sufficiency in energy. Within the next year, as part of the search for high-leverage policies, we will be able to test such a change in tax and energy policies in the National Model.

Changing Economic Patterns

The challenge to the nation in the 1980s will be to cope with change. I believe we are at the top of a long-wave peak. If so, we are nearing the end of a technological era.

Our present technology is mature. Since 1960 there has

not been a major, radically new, commercially successful technological innovation comparable to aircraft, television, nylon, antibiotics, computers, or solid-state electronics. The things that are truly new do not fit into the present technological infrastructure; they must wait until the next great technological wave.

Technological change does not progress smoothly without interruption. Each technological upsurge of the long wave has its own integrated pattern of technology that builds in an orderly step-by-step manner. But a discontinuity occurs between the waves. The orderly pattern of the last 30 years did not grow smoothly out of the 1920s. Aircraft were not an evolutionary extension of railroads. Television could not be achieved by small improvements to radios.

Now we are probably again at a time of a discontinuity in technology. We are in a hiatus between the ending of our present technological wave and the vigorous development of the next. Such large changes require time. A pause occurs while we shift gears.

We should now look ahead to the next period of major technological change beginning 20 years hence and prepare for a restructured society. The future may be as different from the present as the present is from 1910. We will have new energy sources, new patterns for living, new transportation, and a new mix of technology. Some of the changes may represent reversions to earlier patterns. For example, prior upsweeps of the long wave have been fueled in turn by wood, coal, and oil; now there is serious talk of returning to coal. With rising energy costs and the need for greater transportation efficiency, there could be a return to rail transportation.

The pattern of the next technological wave is not yet clear. Indeed, one may be mistaken to believe that change will continue to mean technological change. The future may be more a time of social than technological change. In the last several hundred years, the frontier of change has shifted from one aspect of society to another. At one time, the challenge was to create new forms of government, and at another time new forms of literature. It is entirely possible that we have been through the technological age. I do not mean that technological change will stop — only that it will fit into the normal fabric of society instead of being the focus of innovative attention.

Toward New Understanding of National Systems

Future innovation may focus on society itself, on social change and understanding social change. Less is now known about economic behavior and how to control it than is known about technology. Technological systems have become understood through simulation models. The theory and techniques of modeling have now progressed to where they can deal with the far more complicated social and economic systems.

The System Dynamics National Model is a step toward better understanding of socio-economic systems. The Model has now reached a stage at which it can begin to show the reasons for previously puzzling economic behavior. Experiments can now be conducted in search of more effective corporate and national policies.

As I have noted in the foregoing discussion of economic and energy policy, the Model is designed to explore such issues as the effect of changes in taxes, reasons for declining productivity, wage and price controls, energy policies, balance of payments and shifting exchange rates, and the effect of an older population on retirement plans and stability of the Social Security system.

One immediate concern arises out of the conflicting economic forces of inflation and deflation and how to steer a course between.

In the next year we will be extending our investigation of the economic long wave. We will be comparing behavior as seen in the National Model with historical information and with the current economic situation. If the Model continues to suggest that we are currently at a long-wave peak, the next step will be to examine alternative policies for avoiding the difficulties of a traditional depression. Such policies must facilitate movement of people to economic sectors where they can find employment, cope with debt left from the capital-investment boom, and make an orderly transition to energy and technology of the future.

Further Readings

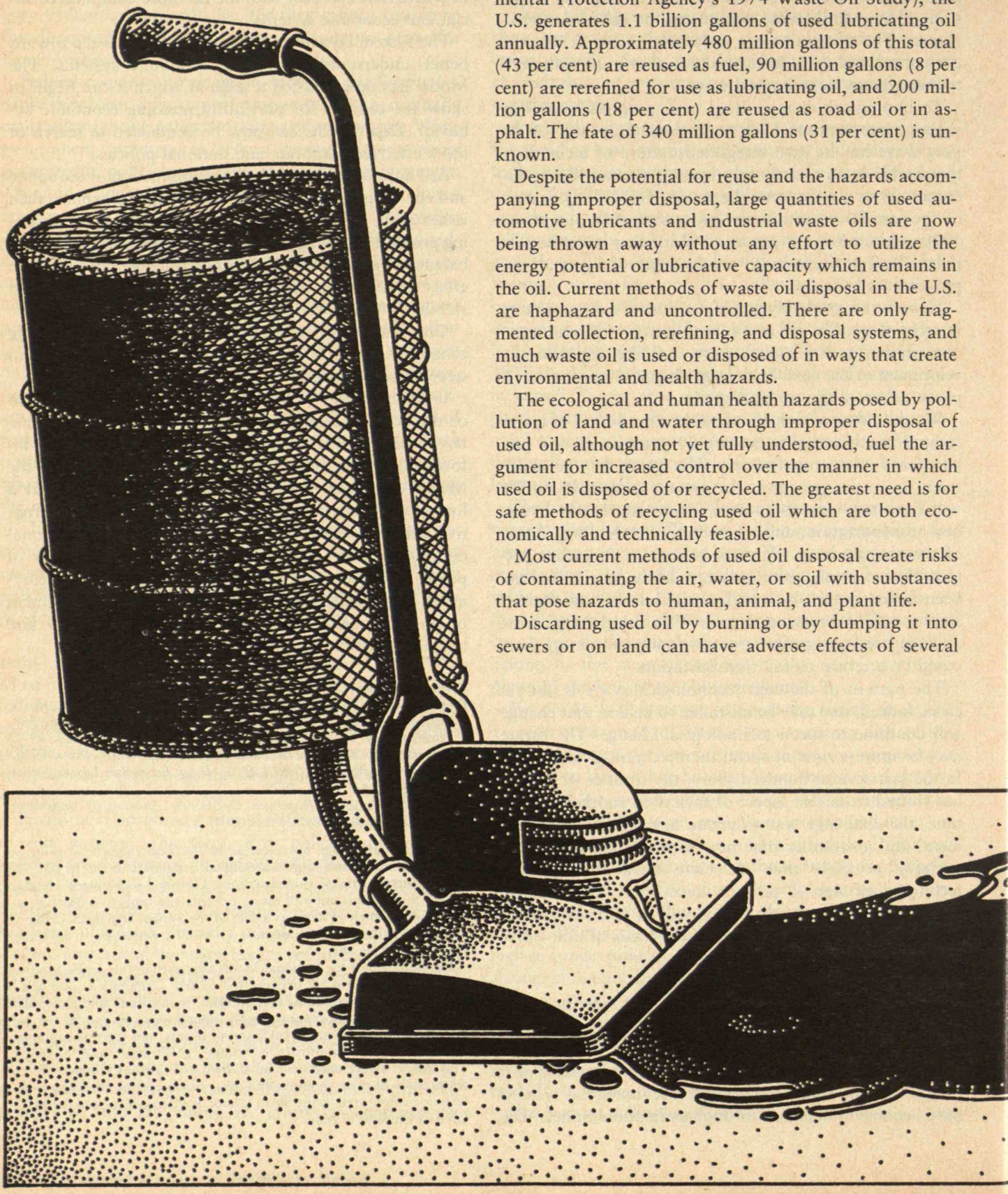
Forrester, J. W., *Industrial Dynamics;* Cambridge: M.I.T. Press, 1961.
Forrester, Jay W., *Urban Dynamics;* Cambridge: M.I.T. Press, 1969.
Forrester, Jay W., *World Dynamics;* Cambridge: M.I.T. Press, 1971.
Forrester, Jay W., *Collected Papers;* Cambridge: M.I.T. Press, 1975.
Forrester, Nathan B., *The Life Cycle of Economic Development;* Cambridge: M.I.T. Press, 1973.
Mass, Nathaniel J., *Economic Cycles: An Analysis of Underlying Causes;* Cambridge: M.I.T. Press, 1975.

Jay W. Forrester began his career as an electrical engineer working on servomechanisms and large-scale digital computers in the M.I.T. Servomechanisms, Digital Computer, and Lincoln Laboratories. He then turned to the application of these concepts and tools to industrial, social, and economic systems as leader of the System Dynamics Group in the Sloan School of Management at M.I.T., where he is now Germeshausen Professor.

Development of the National Model described in this article is now a cooperative undertaking between the System Dynamics Group and a group of sponsors including corporations, foundations, and individuals who provide financial support, supply input information, act as a sounding board for preliminary evaluation of results, and serve as communication links from the project to business, government, and the public. This article is developed from an address by Professor Forrester to representatives of these sponsors and other organizations attending a conference cosponsored by the Sloan School of Management and the M.I.T. Club of Chicago in May.

Used Oil: Collection, Recycling and Disposal

William A. Irwin



According to the best available estimates (the Environmental Protection Agency's 1974 Waste Oil Study), the U.S. generates 1.1 billion gallons of used lubricating oil annually. Approximately 480 million gallons of this total (43 per cent) are reused as fuel, 90 million gallons (8 per cent) are rerefined for use as lubricating oil, and 200 million gallons (18 per cent) are reused as road oil or in asphalt. The fate of 340 million gallons (31 per cent) is unknown.

Despite the potential for reuse and the hazards accompanying improper disposal, large quantities of used automotive lubricants and industrial waste oils are now being thrown away without any effort to utilize the energy potential or lubricative capacity which remains in the oil. Current methods of waste oil disposal in the U.S. are haphazard and uncontrolled. There are only fragmented collection, rerefining, and disposal systems, and much waste oil is used or disposed of in ways that create environmental and health hazards.

The ecological and human health hazards posed by pollution of land and water through improper disposal of used oil, although not yet fully understood, fuel the argument for increased control over the manner in which used oil is disposed of or recycled. The greatest need is for safe methods of recycling used oil which are both economically and technically feasible.

Most current methods of used oil disposal create risks of contaminating the air, water, or soil with substances that pose hazards to human, animal, and plant life.

Discarding used oil by burning or by dumping it into sewers or on land can have adverse effects of several

The reuse of lubricating oil avoids pollution of land and water, and saves energy as well.

America is now beginning to follow the example of Europe, and some states are passing legislation to organize for the collection and recycling of used oil.

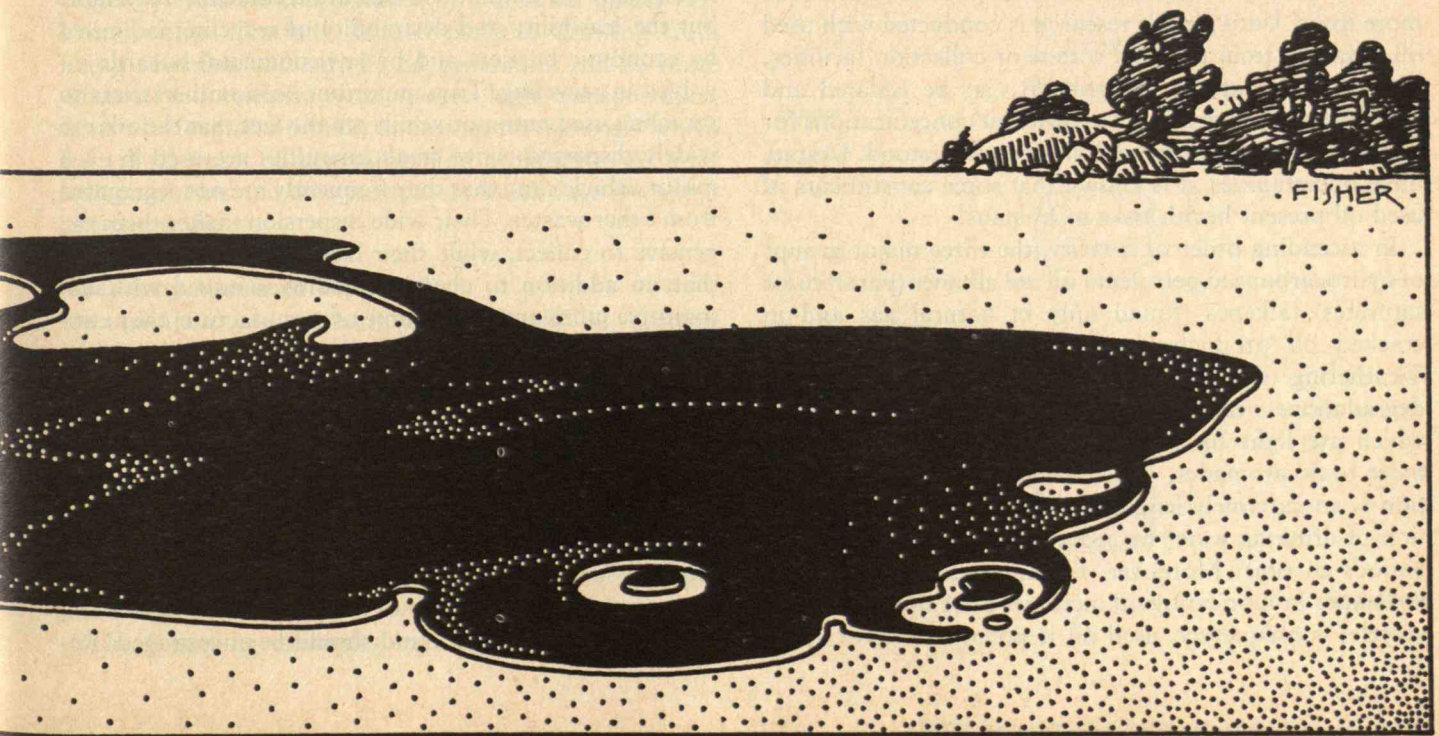
kinds. Used oils dumped into drains foul connector sewers and treatment plants, thus increasing maintenance costs, reducing treatment efficiency (resulting in more contaminated effluent), and sometimes causing shutdowns. Disposal on land may render the soil unproductive and contaminate surface and groundwater supplies. Uncontrolled burning of untreated used oils, particularly automotive lubricants, may cause hazardous and unlawful emissions of heavy metal particulates, principally lead. In addition, burning may foul incineration equipment and present risks of fire or explosion.

As mentioned earlier, large quantities of used oil are "recycled" through use as road oil or for other dust suppressant purposes. Applying used oil to unimproved road surfaces results in varying degrees of oil runoff, depending on the rate of application and the characteristics of the soil surface. This runoff pollutes surface waters with oil, additives, and any other contaminants the oil may have accumulated. In recent years, used oil applied as a dust suppressant has been found to contain such toxic or carcinogenic chemical contaminants as 2, 3, 7, 8-tetrachlorodibenzodioxin, polychlorinated biphenyl (PCB), and 2, 4, 5-trichlorophenol.

Disposal or recycling of used oil into bodies of water can severely disrupt surface water ecology. First, since the hydrocarbons in oil decompose microbially, their presence in water fosters growth of microorganisms which deplete the waterborne oxygen supply available to other aquatic life. Oxygen depletion, in turn, can impair reproduction and growth of fish and other organisms. Second, oily films on the surface, by blocking sunlight from aquatic plants and by reducing surface aeration, also prevent replenishment of waterborne oxygen by impairing both photosynthesis and direct entry of airborne oxygen. Third, oil contains noxious compounds which even in small concentrations can disrupt the feeding habits of water life. Finally, oil may contain toxic components which poison fish through their food chain.

Of serious concern is the likelihood that improper disposal or recycling of used oil can contaminate drinking water supplies. Not only can this render the water unpalatable, but also, to the extent that used oil contains substances that are carcinogenic or otherwise toxic, such contamination can result in serious hazards to human health. Because of their complexity, it is important to discuss the toxic qualities of used oil in some detail.

At least half a dozen components of mineral oil, including the polycyclic aromatic hydrocarbons, 3:4 benzpyrene, dibenzanthracene, and dibenzpyrene, have been shown to induce carcinomas. Indeed, the polycyclic aromatics are thought to be the principal carcinogens in used oil. Yet, the most serious problem in this area is lack of knowledge. No testing of used oil performed by the E.P.A. laboratories or by others has involved a comprehensive analysis of the hydrocarbons of used oil; rather, testing has dealt almost exclusively with identifying metals and analyzing their effects. Since the only metal found in significant quantities in used oil which is suspected of having carcinogenic effects is cadmium, much time has been lost in this area of used oil carcinogenesis research. Little is known about how carcinogenic substances act and how they affect the body,



Mark Fisher

and about how to mitigate their adverse effects. Chemical carcinogenesis, a long-neglected area of cancer research, and oil toxicology are only now beginning to be seriously studied. Studies and experiments should be funded to determine whether improper disposal of used oil contributes to an increase in the incidence of cancer, and if so, what segments and percentages of the population are exposed to what levels of risk.

Not Fade Away

Measurement of the harmful impact of improper used oil disposal is complicated by the fact that the amount of used oil disposed of does not, in itself, determine the toxicity of the constituents of the oil. Many other factors — susceptibility of the affected organism and the potency and physical and chemical form of the toxins — must be taken into account when the potential toxicity of used oil is calculated. Levels of used oil pollution found to be "safe" in a laboratory usually do not take into account long-term biological exposures associated with the growth of cancers, not can they account for the way in which organisms are affected by carcinogens. More information is needed about the effect on humans of various amounts and intensities of concentrations of carcinogenic substances.

Moreover, information about the ultimate fate of some used oil constituents in water is inadequate. The persistence of some hydrocarbons in water is unknown, and it may be that continual releases of used oil into water supplies result in a gradual buildup of carcinogenic material. Further, the interaction of toxic components of used oil with other substances in water may render them even more toxic. Until further research is conducted with used oil obtained from polluted waters or collection facilities, and until its various components can be isolated and analyzed, the range of risks at different concentrations for different periods of time will not be understood. Despite these uncertainties, it is known that some constituents of used oil present health risks to humans.

In ascending order of toxicity, the three major groups of hydrocarbons in petroleum oil are alkanes (paraffins or saturates), alkenes (found only in natural gas and in cracked oil products, not in crudes) and aromatics. Weathering (i.e., oxidation, evaporation and biological degradation) occurs most readily among the alkanes, which are light fuels with low boiling points. For the more toxic aromatics, which are heavier fuels, degradation is an extremely lengthy process, so that contamination of drinking water by aromatics will persist for long periods of time. Moreover, the amount of polynuclear aromatics in lubricating oil increases after use in a motor vehicle; consequently, used oil is potentially more toxic than unused oil.

The breakdown between industrial and automotive lubricants in a particular nation varies with the kind and extent of its industrialization and with its automotive population. However, used automotive oils average about 60 per cent of the total and can be treated as a single category.

Acid and Clay to Rerefine

Used automotive lubricants undergo a standard rerefining process. First, the sediment in the dirty oil is allowed to settle. Then the oil is decanted and heated under pressure, in order to evaporate the water and other volatile components. The oil is then treated with sulfuric acid, which precipitates the impurities. The acid sludge is drained off; while this sediment can be used as landfill, the problem of its disposal has not been completely solved. The oil is then steamed, mixed with decoloring clay, and filtered.

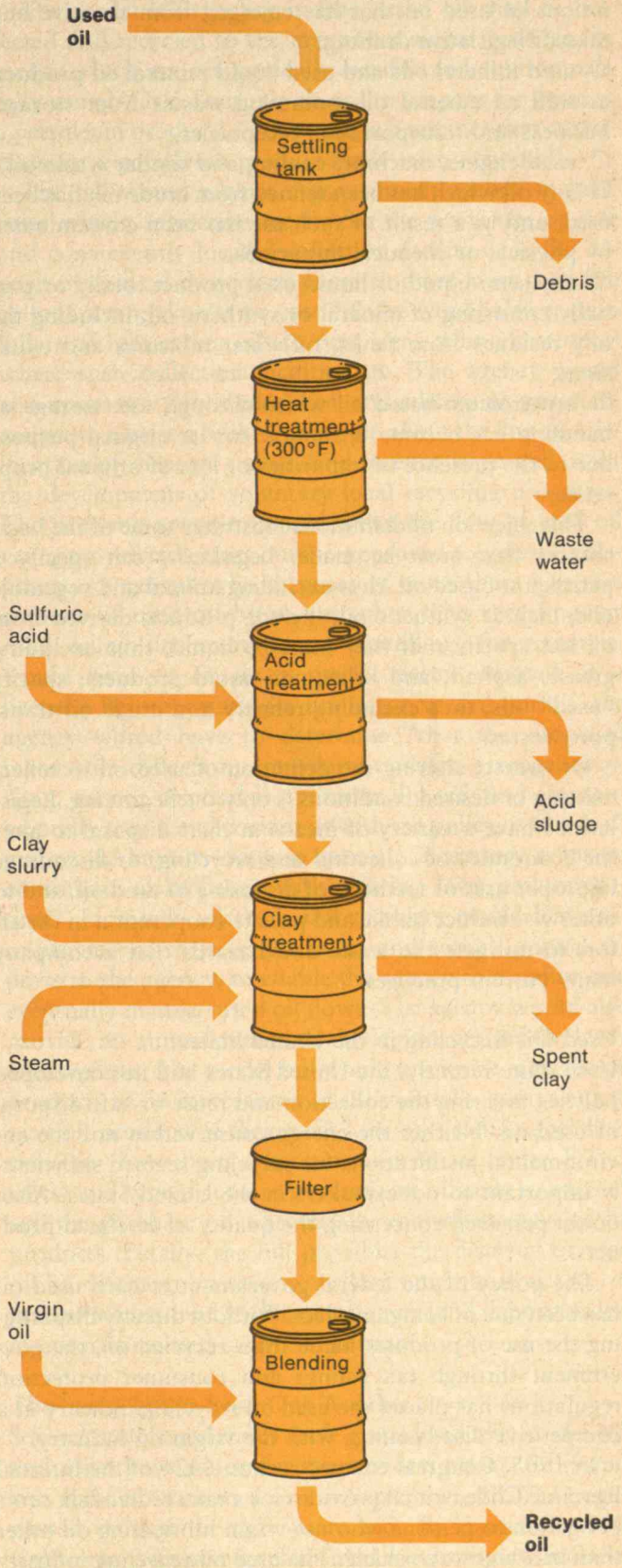
The resulting "base stock" oil may then be blended with virgin oil and whatever additives are needed to bring it to the desired lubricant specifications.

One variation on this method is to substitute centrifuging and vacuum distillation for the acid treatment stage. Instead of acid sludge, this method results in a high-ash fuel by-product. Another variation is to introduce propane into the oil before the acid treatment stage. The oil dissolves in the propane, the solution is extracted from the impurities, and the oil is then separated from the propane. The oil is then subjected to the acid and clay treatment stages using only about half as much acid and clay.

Virtually all automotive oils are technically recyclable but the feasibility and desirability of recycling is limited by economic barriers and by environmental hazards involved in recycling. Two important economic barriers to recycling used automotive oils are the fact that the oils are widely dispersed (since small quantities are used in each motor vehicle) and that they frequently are not segregated from other wastes. Their wide dispersion makes them expensive to collect, while their lack of segregation means that, in addition to chemical additives mixed with automotive lubricants at the time of manufacture, they contain other foreign matter which is also expensive to remove.

The environmental hazards depend on the method of recycling used. The standard rerefining process produces acid sludge, which cannot safely be disposed of except in landfills suitable for hazardous wastes, and then only after neutralization of the acid content. Hazardous-waste disposal sites are scarce, however, and neutralization is expensive. Some variations of the standard process avoid the acid sludge problem, and should be encouraged. Re-

Acid-clay treatment is standard for rerefining used automotive lubricating oils. After the sediment in the dirty oil settles, the oil is heated under pressure to evaporate the water and volatile components. Treatment with sulfuric acid follows. This precipitates the impurities, which are drained off as acid sludge. The oil is then steamed, mixed with clay, and filtered, resulting in a base stock that can be blended with virgin oil or other additives to achieve the desired lubrication specifications.



processing, a much simpler process which produces oil used primarily as a fuel supplement, presents a different hazard. Since metallic and chemical impurities remain in the reprocessed oil, burning it can result in the release of toxic air pollutants unless adequate control measures are implemented.

Industrial lubricants, in contrast to automotive oil, involve a number of different types and uses; these include metal-working oils, hydraulic oils, gearbox oils, spindle oils, electrical oils and process oils used in tanning and in the manufacture of rubber and textiles. The composition of used industrial lubricants depends on their use and degree of segregation from contaminants or other wastes. But there is one advantage to offset the disadvantage of heterogeneity: they are generally less dispersed than automotive oils and therefore more readily available either for reuse in-plant as lower-grade lubricants or for collection and recycling.

The technical processes for preparing used industrial oils for recycling vary with the type of oil, but two types of oil present special problems. These are:

- ☐ emulsions; i.e., stable suspensions of about five per cent oil in water, which are used to lubricate, cool, and cleanse in such metal-working operations as milling, drilling, rolling, and drawing;
- ☐ oily liquids; similar to emulsions but less stable and often higher in oil content, which result when oil tanks are washed with water.

Recovering the oil from emulsions and washwater involves "breaking" the suspension through use of chemicals and in some instances heat. The few facilities which currently exist for this purpose at individual plants perform poorly. Centrally located facilities drawing from many emulsion and oily liquid generators can be more efficient and effective, but involve high transportation costs (due to non-oil bulk) and other service costs which individual waste oil generators find prohibitive. As a result, emulsions and oil-wash waters usually are discarded as wastewater.

The Many Names of Waste Oil

Because there are so many kinds of used oil, each of which presents different hazards and different problems of collection and recycling, the legal definition of used oil is a critical part of any program to control use and disposal. Not only may an underinclusive definition omit types of oil that pose special environmental or health hazards, but an overinclusive definition may impose heavy economic and technological burdens on the private sector and irksome administrative problems on the regulatory agency.

The following examples indicate the range of defi-

nitions of used oil that has emerged from the give and take of legislative drafting:

- ☐ used mineral oils and used liquid mineral oil products as well as mineral oil-containing wastes from storage, business and transportation receptacles,
- ☐ used engine, machine, cooling and similar waste oil,
- ☐ any oil which has been refined from crude oil, has been used, and as a result of such use has been contaminated by physical or chemical impurities,
- ☐ any semi-liquid or liquid used product totally or partially consisting of mineral or synthetic oil, including the oily residues from tanks, oil-water mixtures and emulsions,
- ☐ a petroleum-based oil which through use, storage or handling has become unsuitable for its original purpose due to the presence of impurities or loss of original properties.

This selection of definitions illustrates some of the basic choices that must be made. Legislators can specify a petroleum-based oil, thus excluding animal and vegetable oils; include synthetic oil; include products derived from oil but specify that they must be liquid, thus excluding grease, asphalt, and other non-liquid products; specify "used" oils, thus excluding refinery and crude oil transport wastes.

Of course, altering the definition of used oil to reflect existing or desired conditions is only the beginning. Legislatures have a variety of means at their disposal to alter the economics of collection and recycling, to discourage improper uses or methods of disposing of used oil, and to otherwise induce public and private cooperation in the effort to mitigate the waste and hazards that accompany many current practices.

Used Oil Recycling in the United States

Until quite recently, the United States had not developed policies favoring the collection and reuse or safe disposal of used oil. Neither the energy conservation nor the environmental justifications for recycling seemed sufficiently important to policymakers in the United States. Also, doubt persisted concerning the quality of rerefined products.

The policy of the federal government toward used oil has been one of benign neglect. Without directly disparaging the use of products made from recycled oil, the government through tax rulings and consumer protection regulations has placed the used oil recycling industry at a competitive disadvantage with the virgin oil industry.

In 1965, Congress enacted section 6424 of the Internal Revenue Code, which provides for a tax credit of six cents per gallon to persons who use virgin lubricating oil other than in a highway vehicle. The used oil recycling industry sought to claim this credit, on the theory that virgin oil blended into used oil is not used in a highway vehicle. The I.R.S. denied the credit, holding that blending does not constitute a "use" within the meaning of section 6424, inasmuch as the blended product is still fit for use as a lubricant. This portion of the ruling would have been correct if the I.R.S. had permitted non-highway users to claim the credit on the virgin portion of the blended product. Otherwise, the credit could have been claimed twice, once by the person blending the oil, and once by the final user.

However, the I.R.S. also denied the credit to final non-highway users, on the theory that the consumer is using not new oil, but rather, "nontaxable" used oil. This portion of the ruling seems incorrect, inasmuch as part of the "nontaxable" used oil, *i.e.*, the virgin blending stock, has in fact been taxed. As a result of this ruling, the total tax cost of virgin oil blended with used oil is higher than that of pure virgin oil — a result that seems inconsistent with the apparent purpose of section 6424 to benefit non-highway vehicular and non-vehicular users of lubricating oils. Moreover, the effect of the I.R.S. ruling is to reduce the competitive advantage of blended used oil over virgin oil, even though the total cost (tax and non-tax) of the blended product may still be lower than that of pure virgin oil.

Since 1964 the Federal Trade Commission (F.T.C.) has required lubricating oil products made from used oil to be clearly advertised and labeled as "previously used." This regulation was promulgated on the basis of F.T.C. findings that consumers prefer virgin lubricating oils, that they assume they are buying such products unless the containers are otherwise labeled, and that therefore the failure to label previously used products as such is an unfair method of competition and a deceptive trade practice. The F.T.C. made no provision for labeling the product as appropriate for a particular use, and it maintains that neither the value of the recycling industry's service in providing proper disposal of used oil nor the functional equality of its products with virgin oil products was "germane" to its decision.

Although efforts to overturn by statute the I.R.S.'s position on blended oil products have so far failed, other developments at the federal level may, in the long run, lead to a change in the F.T.C.'s view on labeling of used oil products. Further, some steps are presently being taken to encourage voluntary recycling and to increase governmental agencies' use of recycled oil products.

The principal force behind these developments in the Energy Policy and Conservation Act, enacted in December, 1975. The Act requires the National Bureau of Standards (N.B.S.), "as soon as practicable," to "develop

test procedures for the determination of substantial equivalency of rerefined or otherwise processed used oil or blend of oil . . . with new oil for a particular end use," and to report the procedures to the F.T.C.

When the N.B.S. reports to the F.T.C., the F.T.C. is required to prescribe labeling standards within 90 days which "permit any container of recycled oil to bear a label indicating any particular end use for which a determination of substantial equivalency has been made" in accordance with test procedures the F.T.C. adopts by rule on the basis of the N.B.S. report. Within the same period, the E.P.A. is required to adopt standards for labeling of *all* containers of oil "relating to the proper disposal of such oils after use . . . which shall be designed to reduce, to the maximum extent practicable, environmental hazards and wasteful practices associated with the disposal of such oils after use." Once the F.T.C. rules governing labeling of recycled oil go into effect they will preempt any inconsistent F.T.C. rule and any inconsistent state or local law.

The results of these congressional mandates are beginning to take shape. The N.B.S. will send its first report on test procedures for fuel oils to the F.T.C. this summer. Meanwhile, the E.P.A. is drafting regulations, under the authority of the Energy Policy and Conservation Act and the hazardous waste management provisions of the Resource Conservation and Recovery Act, which attempt to establish maximum levels of contaminants permissable for alternative uses of used oils. (For example, oil whose part-per-million lead content is too high shall not be burned for fuel.) The E.P.A. and the F.T.C. are currently exploring the feasibility of combining in a joint label the messages they are directed to display by the E.P.C.A.

In the Federal Mold

The Department of Energy is also involved with used oil recycling efforts. It has recently published a Used Oil Recycling Kit, a project initiated by the F.E.A., one of the D.O.E.'s predecessor agencies. Its design enables community organizations to establish programs for collecting and recycling oil, principally from the increasing number of individuals who change their own automotive oil. The F.E.A. also sponsored the preparation of model used oil recycling legislation. The D.O.E. has encouraged state governors to include used oil recycling programs in the energy conservation plans which receive federal support under the Energy Conservation and Policy Act, and has suggested that the model serve as a departure point for state and local revisions. Although designed to be adaptable to a variety of circumstances, the model bill contains several elements of a comprehensive approach to managing used oil collection and recycling.

The model bill's policy is that "used oil shall be collected and recycled to the maximum extent possible, by means which are economically feasible and environmentally sound." It defines *recycle* as "to prepare for reuse as a petroleum product . . . or to use in a manner that substitutes for a petroleum product made from new oil."

The bill would require a government agency to issue rules which "prescribe means for the provision of safe and conveniently located collection facilities for the deposit of used oil by persons possessing not more than five gallons at one time at no cost." Rules would also require sellers of lubricating oils to post signs telling customers where such collection facilities are. The agency would also sponsor a public education and a licensing program, assigning a liaison to inform people about the law and the location of disposal points, and to encourage and assist the development of voluntary local recycling programs. The licensing program would direct the flow of used oil via approved collectors only to approved recyclers or disposers. (A person who disposes of more than a certain amount of used oil by means other than recycling, by road oiling, incineration, or landfilling, for example, would have to obtain a special permit instead of a license.) Before granting a license or special permit, the agency would have to determine "that the proposed means for collection, transport, transfer, storage, recycling, use, or disposal is operationally safe and environmentally sound and consistent with the policy of this Act" and would have to "impose terms . . . necessary to insure continuous compliance with existing laws and regulation." Licensed collectors and recyclers would leave receipts, record their transactions, and submit annual reports to the agency, to enable the agency to monitor and eventually manage used oil flows. The agency would also provide an annual report to the legislature on the law's effectiveness. The model bill would authorize recycled oil products to be represented as substantially equivalent to new oil products if they meet new oil product specifications (or have been determined to be so under F.T.C. rules) and would require government officials to encourage the purchase of substantially equivalent recycled oil products. Finally, the bill prohibits the disposal of used oil by discharge to sewers, surface or ground waters, or marine waters, and by incineration or land deposit unless in accordance with a special permit.

The States Learn from One Another

Several state legislatures have considered the model bill and some have enacted it more or less intact. California was the first state to do so in September, 1977; Oregon passed its law in that year, too. By January, 1979, California is to have implemented requirements similar to

those of the model bill governing registration of used oil collectors and recyclers, for example.

In late July the California Solid Waste Management Board received a draft of the rules required by the law to govern registration of collectors, haulers, and recyclers; public hearings are scheduled for early September, when the Board's staff will mail invitations to all service stations in the state to participate as collection centers. Even without formal invitations, over 700 service stations had written in to volunteer for this role as of mid-July and many more are expected to respond to the invitations.

The Board's staff has also drafted language for the signs which retailers of used oil must post to tell customers the locations of convenient collection centers, and the signs that will be posted by the collection centers themselves. One problem encountered in California is the overlap with its liquid waste and hazardous waste hauler licensing requirements. These licenses are supervised by other agencies. The Board's counsel has suggested that the delegation of its functions may be implausible, however, thereby making efforts to simplify procedures somewhat more difficult.

Oregon's law became effective in January, 1978, but its program did not get underway until Ernest Fraim came to manage it. Oregon had a chance to learn the extent of its problems and the resources it could use to cope with them before proceeding to establish a permanent program: much research had been conducted in more populous California before its bill was enacted. A survey was conducted in the Portland area to learn what people knew about used oil recycling and disposal, and what they did with their used oil. This survey will be extended to selected towns in rural parts of the state. The media will be used to inform the public and to encourage the establishment of collection centers in these survey areas. A year hence the Department of Environmental Quality's personnel will return to see what effects these efforts have had and will then make recommendations on whether such an approach would be effective on a state-wide basis. Meanwhile, Mr. Fraim is preparing a brochure on used oil recycling for the general public and a list of the persons who collect used oil, at what prices, and for what purposes (rerefining, reprocessing, road oiling, etc.).

In Portland, efforts are currently focused on improving the network of collection centers to handle the larger quantities of oil brought in as the public learns of the energy conservation and environmental protection benefits of recycling. Although the Oregon law does not provide for licensing or record keeping, the Department will try to learn what volumes of oil are being handled by rerefiners, reprocessors and road oilers, in order to determine how much used oil may be being dumped.

There are, appropriately, as many different approaches as there are state circumstances. Maryland was a state that long ago began to regulate oil handlers; as a result the bill enacted there in May was designed to increase Maryland's ability to conduct comprehensive used oil management. Utah's law, one of the first of the recent spate of bills enacted, has as its purpose "to establish an effective program to promote the rerefining of used oil." Maine has chosen to contract with a private firm to set up a system for recovery, stockpiling, and recycling of used oil. Vermont has for some time coordinated efforts of private oil companies which provide storage tanks, towns that provide sites, and the National Guard, which provides transportation, in a state-wide program to collect used oil for sale to rerefiners or reprocessors.

How Europeans Recycle Oil

The European experience furnishes useful insights into how a recycling program could be implemented in the United States. Prior to 1975, several European nations had taken steps to promote collection and reuse of used oil. The Europeans have a particular vulnerability to oil shortages, a lack of space to absorb adverse environmental effects of improper disposal, and have learned to expect high prices of oil products in Europe. The programs they have implemented range from relatively simple tax incentives that encourage recycling, to more complicated and mandatory collection, reuse, and disposal statutes.

In Italy and France, tax incentives to encourage recycling of used oil are in effect. Italy exempts products made from used oil from 75 per cent of the tax levied on crude oil products. If a company authorized to rerefine its own oil meets certain standards for the product, the remaining 25 per cent of the tax is also waived. Similarly, France does not impose an oil excise tax on products made from used oil, although this practice is based on a principle of French tax law which holds that a product once taxed may not be taxed again, rather than on a policy of promoting used oil recycling. In both nations, the indirect subsidy enables recyclers to sell their products at prices lower than those for comparable products which are produced by crude oil refineries. But these tax incentive programs do nothing to ensure that improper disposal methods are curtailed for oil which is not recycled into new products.

In Denmark all persons have an obligation not to cause pollution by improperly storing, transporting, or disposing of used oil. To fulfill this obligation, local governments are required to establish used oil collection facilities. The Danish system facilitates collection and recycling with a locally administered program. Unlike the French and Italian programs, the Danish approach po-

tentially could eliminate the adverse ecological and health effects of improper disposal, because it imposes direct controls on the final disposition of used oil.

After encouraging rerefining by tax preferences and subsidies for 20 years, Germany enacted a comprehensive, self-supporting national system in 1968, which both encourages recycling and ensures proper disposal of unrecycled oil. Their system is one of reporting requirements and program-funded, nationally coordinated collection and disposal contracts. All persons who import or produce certain lubricating oils (including rerefiners) pay, in addition to an existing tax on mineral oils, a compensation fee, which goes into a special fund reserved for the support of the disposal or recycling of used oils by high-temperature incineration or rerefining. These methods are the only two deemed safe from environmental and public health viewpoints.

The German firms' contracts obligate them to pick up all amounts of used oils over 200 liters in the district assigned to them at no charge to the user unless the oils contain more than 10 per cent foreign matter. They must also provide suitable containers for lesser amounts for later collection, and record their costs.

The Germans have a federal program which is designed to minimize program costs while encouraging recycling. By placing the financial burden of administrative costs and compensation payments on those using the oil who in turn pass these costs to the users, costs to the government are kept to a minimum. Further, since only lubricating oils subject to the existing mineral oil tax are also subject to the disposal fund compensation fee, the paper work, procedures, and personnel for levying the fee are integrated almost completely with the collection of the mineral oil tax, resulting in substantial administrative cost savings. Finally, the compensation payments encourage collection and recycling of oils that otherwise could not be handled economically in the private sector.

In June, 1975, the Council of the European Communities adopted a directive on waste oil disposal intended to harmonize the laws of member nations in order to reduce "unequal conditions of competition" and to achieve "one of the aims of the Community in the sphere of protection of the environment." Since not all member nations have responded to the Directive, and since the adequacy of compliance by those which have responded is uncertain, it remains to be seen how effective the Directive will be in achieving these goals. Nevertheless, the C.E.C. action is a significant move toward international cooperation to reduce the environmental costs and resource losses which accompany improper disposal of used oil. The provisions of the 1975 Directive are patterned after several elements of the German statute. If safe collection, disposal, regeneration or combustion, and compliance with the prohibitions of the Directive cannot be realized without government intervention, the member nations are to take steps necessary to ensure collection and disposal, perhaps by assigning enterprises to collect from certain zones. The unrecovered costs of rendering this service, plus a reasonable profit, may be paid to the enterprises as indemnities. The indemnities must be financed in accordance with the "polluter pays principle," perhaps by charges imposed on used oil, on newly refined oil, or on products which when put in service generate used oil.

Although the Directive requires the financing of indemnities in accordance with the "polluter pays principle," the amount of the indemnities must "not cause any significant distortion of competition or . . . give rise to artificial patterns of trade in the products." It is not clear how this will be accomplished or enforced. Another problem is that as of June 16, 1977, the deadline for compliance, no member nation had informed the Commission that it had implemented the measures necessary to comply with the Directive. Even the amendments to the German law, designed in part to comply with the provisions of the C.E.C. Directive, did not pass until December, 1977. Other nations are currently negotiating with the C.E.C. Commission on what steps will constitute adequate compliance with the Directive's provisions.

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Versions of this article have appeared in the *Ecology Law Quarterly*, 6:4, under the title, "Used Oil: Comparative Legislative Controls of Collecting, Recycling, and Disposal," and in *Resource Conservation: Social and Economic Dimensions of Recycling*, edited by D. Pearce and I. Walter, New York University Press, 1977.

Can We Save Energy By Taxing It?

Direct taxation will help manage our transition to higher energy prices. But to pass the conservation tax credits now being proposed would be to send a small boy on a man's job.

John F. Boshier

A principal goal of U.S. energy policy is to prevent energy prices from rising as much as we now fear they will. Conservation has been seized upon as a principal initiative, and the two most important components of President Carter's policy — both stimulated by the goal of conservation — are the investment tax credit and taxes on energy sources.

But "energy conservation" means different things to different people. Many different views — ranging from the advocacy of a true *laissez-faire* market to analyses of conservation opportunities based on the second law of thermodynamics (which show that the absolute efficiency of energy use is very low) — have been brought by previous authors to the pages of this magazine. The present article considers the political and economic issues raised by the two principal thrusts to conservation in the current National Energy Plan.

The conclusions are:

☐ Taxation to increase the price of energy, though both unpopular and disruptive, will enable the economic and social effects of higher energy prices — which are inevitable — to be monitored and even managed; and taxes can be used to stimulate necessary new technologies.

☐ The conservation tax credit, which is aimed at lowering the price of capital relative to that of energy for applications where there is a tradeoff, is working against a long-term U.S. policy of taxation which encourages investment in energy-intensive equipment to substitute for labor. The new tax credit does not reverse this trend, nor does it significantly raise the rate of return on an investment in conservation; activities that conserve or substitute for energy by promoting employment rather than extra capital investment should be our goal.

Energy and Capital: Both Go Up Together

A guiding principle of the National Energy Plan is that "healthy economic growth should continue" and that full employment be promoted. In other words, it is desirable to lower the ratio of energy use to gross national product in the U.S.

But can we expect to reduce energy use without influencing the use of other factors of production. After all, energy is only one input to the manufacturing process. If output is to be sustained or even increased while energy consumption is reduced, then some other input must substitute for the energy that has been saved. What factor can substitute for energy? Attempting to answer this question, Ernst R. Berndt and David O. Wood of the M.I.T. Energy Laboratory have used a "factor substitution" model to determine the extent to which energy, capital, labor, and materials are interchangeable in U.S. industry. Their purpose is to define for each of these factors an elasticity of substitution.

This may be expressed in terms of a price elasticity; for example, the price elasticity of capital with respect to energy (called the "cross-price elasticity") is the change in the consumption of capital goods per unit of change in the price of energy. Two factors are defined as being substitutes, independent, or complements according to whether the cross-price elasticity is positive, zero, or

negative, respectively. For example, suppose the price elasticity of coffee with respect to tea is found to be 0.5. This means that for each one-per-cent rise in coffee prices, the use of tea increases 0.5 per cent; the two are substitutes.

Common sense applied to most industrial and residential processes involving the use of energy suggests that energy is substitutable with inputs of capital, labor, and materials in producing a given level of product or service. For example, trade-offs between energy and capital are clearly available in refrigerators. Increases in the purchase price of refrigerators of a given capacity are associated with decreases in expected energy consumption. Hence the proposal for a tax credit which would lower the price of an energy-efficient refrigerator, inducing consumers to purchase increased efficiency and therefore in the long run to decrease their energy consumption.

But are there other possible effects of such a tax credit? Might consumers also respond by purchasing other capital-intensive options, such as frost-free or ice-making features, which would have the effect of increasing energy use rather than of decreasing it, as intended? We cannot know the net effect on energy use of a tax credit without examining both types of substitution possibilities.

To explore this issue, Drs. Berndt and Wood have developed a simple analytical framework within which to interpret the likely outcome of factor substitution, and they provide an empirical analysis measuring gross and net energy/capital substitution possibilities for U.S. industry. They conclude that for the representative year 1971 energy and capital were gross substitutes but net complements. The first part of that statement — gross substitutes — means that in that year a 1-per-cent decrease in capital price would bring about a decrease of 0.133 per cent in energy consumption, if the costs of other inputs were held constant. But the second part — net complements — means that a 1-per-cent decrease in capital price would have brought about an *increase* of 0.329 per cent in energy consumption if the costs of other inputs were allowed to adjust as they do in the real world.

Drs. Berndt and Wood note that there are many caveats associated with these results, including particularly the level of aggregation. But the results do suggest caution in projecting the effects upon energy use of conservation strategies designed to reduce the price of energy-efficient capital services.

During this period from 1947 to 1971, the total output of U.S. manufacturing grew from $196.2 to $458.0 billion (current dollars), and there was a steady movement toward mechanization. This rapid growth over-rode the direct substitution of capital for energy, so energy consumption continued to increase.

In the same quarter-century the input-output coefficient for labor (the unit input of labor for each unit value of output) dropped from 0.230 to 0.150. But there was no effort to reduce energy consumption, the energy invested per unit of output being unchanged from 1947 to 1971. These trends were more pronounced in some sectors than others; farming, for example, required a much greater input of both capital *and* energy relative to labor in 1971 than in 1947. During this period the price of labor increased at an annual rate of 4.3 per cent, while the annual growth rates of the prices of energy, materials, and capital were, respectively, only 2.1, 1.8, and 0.8 per cent.

Several government policies designed to stimulate investment and economic growth contributed to these results. One was the effective lowering of the cost of capital by investment tax credits, liberalized depreciation, and tax exemptions for interest payments on capital. Another was the increase in employer contributions to Social Security and other insurance and pension schemes. A third was the increase in average workers' wages in real terms. At the same time, energy became cheaper in real terms from 1947 to 1971, and the amount of energy consumed was not of economic or political concern.

This analysis of the past says nothing explicit about the future. But it does raise the issue of how effective are moves to substitute capital for energy (by lowering the price of the energy-efficient capital equipment), which is one of the principal conservation initiatives of the National Energy Plan.

A direct 20-per-cent credit is proposed for residential expenditures through 1984, and a 10-per-cent investment tax credit for industrial and commercial conservation investment is suggested for the latter, through 1982. The objective of this measure from a general economic point of view is to lower the price of capital relative to energy, encouraging a substitution of capital (for example, investment in insulation) for energy (losses through walls).

Though this sounds like a simple incentive system, it is made very complex by the interaction of other tax policies.

How to Reconcile Growth and Conservation

The problem is that the conservation investment tax credit is being proposed in an environment of generally expensive labor, at a time when other federal policies are aimed at stimulating capital investment, economic growth, and productivity. The effort to stimulate conservation through investment in energy-efficient machines runs essentially counter to a persisting government tax policy which encourages productivity and growth by the substitution of machinery for labor. Under these condi-

tions the conservation investment tax credit will have a limited effect, likely to be masked by the continuing trend toward energy-using capital equipment.

The point is that the prices of labor and materials should be brought into the equation, along with those of capital and energy. To conserve energy we need a policy which fosters greater employment of labor — that is, a reversal of the historical trend. The price of labor must fall relative to that of capital and energy if employers are to respond by buying more labor and less energy-using machinery. This has in fact been our experience since 1973. The price of energy has risen in real terms since then (at least until very recently), and industry's response has been to reduce its rate of investment in machinery and energy; additions to capacity have been achieved less by adding machinery and equipment than by adding workers. We thus conclude that an energy policy which raises the price of energy relative to that of labor will in the long run serve the dual goals of energy conservation and full employment.

Present incentives for increased employment, including the corporate employment tax credit and the Comprehensive Employment Training Act, are consistent with these goals. While these programs were not designed to promote energy conservation, they are working in that direction by encouraging the substitution of labor for capital and energy. Wage subsidies — payments to employers to help meet the payroll costs of increasing their labor force — would further these goals; however, while the investment tax credit introduced in the 1960s is considered sound economic policy, the wage subsidy — a similar device in many ways — is viewed as a radical departure.

Stimulating investment by lowering the cost of capital will work against the goals of energy conservation, and this is precisely the effect of present investment tax credits and provisions for accelerated depreciation. The immediate effect is to increase construction of new plant and equipment, increase employment, and raise total output. But the long-range result is to substitute energy-consuming machinery for labor, increasing productivity and reducing employment.

Reduced personal income taxes are advocated to stimulate economic activity by increasing spendable income in the hands of consumers; but such income will lead almost surely to increasing energy consumption.

We conclude that present federal economic policies are in themselves inconsistent with respect to energy conservation. The present National Energy Plan does little to illuminate and nothing to resolve these inconsistencies, and the conservation investment tax credit can hardly have a positive effect on conservation and may contribute to increased consumption.

The Conservation Incentive in an Era of Uncertainty

To be specific, consider how the decision on capital investment in energy conservation is evaluated by a typical small business. Assume a capital expenditure of $10,000 in energy conservation that reduces energy costs by $2,000 in the first year. Assume further that the cost of energy is expected to increase at an average rate of 10 per cent per year, that the capital expenditure is to be fully paid in ten years, that a standard investment tax credit of 10 per cent is available, and that the corporate income tax is 50 per cent. It can be shown (*see box*) that the rate of return on this $10,000 investment is 16.3 per cent. If a conservation investment tax credit of 10 per cent is also available, the rate of return is 18.6 per cent; the investment tax credit for conservation has improved the return by just over 2 per cent.

If the conservation investment yields a larger return, paying for itself in three years, the rate of return with the conservation investment tax credit is 29.5 per cent and without it is 26.9 per cent. And if the payback takes only two years, the rates of return are 41 and 38 per cent, respectively. Clearly the conservation investment tax credit has a minor effect in improving the rate of return on an energy-conservation investment. The important factors are the payback time and the expected inflation in real energy prices.

The crucial question is: What rate of return does a firm investing in conservation require? The Massachusetts Energy Policy Office concludes, after surveying a number of firms, that the answer is at least 25 per cent, compared to about 15 per cent for investments in plant expansion or in other measures to increase productivity. The differential results from uncertainty over future energy price, and it is clear that the conservation investment tax credit does little to close it.

The Massachusetts Energy Policy Office study also showed a trend since 1973 towards more capital- and energy-intensive investment by industry. This is because the price of labor has increased more rapidly than the prices of capital and energy. The effect of investment tax credits — whether enacted in the name of economic growth or energy conservation — is to widen the differential between labor and capital still further. Working against this, however, is the increasing price of energy. The effective reduction in the cost of capital is about 12 per cent, which is roughly balanced by the expected increase in energy prices. So a possible response is that energy will substitute for capital but the two together will continue to substitute for labor — an effect which reduces the usefulness of the conservation investment tax credit as a policy initiative.

Yet another disparity in rates of return on energy-re-

lated investments works against conservation. Most public utilities are limited by regulation to rates of return of approximately 10 per cent. On the other hand, a non-utility company investing in a new energy resource such as cogeneration from its steam boiler or a solar collector requires a rate of return of at least 15 per cent, because these are viewed as being unconventional, risky investments. Thus investments to expand supply are made with a considerable advantage over those to reduce demand. The conservation investment tax credit is aimed toward closing this differential, but the effect is to close it only a few percentage points.

The Homeowner: Larger Leverage

The conservation tax offers more leverage on a homeowner's decision to invest in energy conservation. I show in the example (*see box*) the computation on home insulation leading to the conclusion that the cost can be recovered, on a straight dollar-payback basis, in about three years.

If we make the same assumptions regarding energy costs and lifetime as for a business (10 per cent increase in energy price per year and ten-year lifetime), the internal rate of return on a $10,000 investment by a homeowner that yields a $2,000 saving in energy cost is 40 per cent; if energy cost is assumed to be constant, the ten-year rate of return is 30 per cent. The conservation investment tax credit effectively reduces the cost of the insultation by 20 per cent and increases the rate of return to 46 per cent (37 per cent at constant energy prices).

Are these returns sufficient to encourage a homeowner to invest in conservation? They are indeed, according to studies at the M.I.T. Energy Laboratory. Householders are shown to be willing to make such investments when the rate of return is as low as 16 per cent. The incentive provided by the conservation investment tax credit — an additional 16 per cent on a rate of return which is already above 30 per cent — will not "tip the scales"; people who have not insulated their houses to date are simply unaware of the basic savings available. Some argue — perhaps correctly — that the publicity associated with the conservation investment tax credit will bridge the communication gap and thus overcome the inertia of many homeowners.

While home improvements such as insulation and weatherstripping which may be motivated by the investment tax credit will reduce energy waste, it is not clear that total energy consumption will be reduced by the amount of waste that is prevented. The experience of New Zealand, which has had an incentive program for home insulation for some years, is that the program has been utilized predominantly by families with relatively

Calculating an Industrial Investment in Conservation

The benefits from a conservation investment V_0 by a firm can be regarded as periodic cash flows C_1, C_2 . . . C_n. Given a discount rate or "internal rate of return," i, the net present value at period k, NPV_k, can be calculated from

$$NPV_k = -V_0 + \sum_{j=1}^{k} \frac{Cj}{(1+i)j}$$

The benefit stream Cj has the following components for each year j:

$$Cj = \Delta Ce(1 - y)_j + (y)_j \Delta D + ITCc + ITCs$$

The term $\Delta Ce(1 - y)$ represents the savings in energy (or operating) cost, ΔCe. Since this is expensed before tax calculations are made (i.e., it is deducted from gross profit), profits increase because the output is being produced for less input. Hence tax payments increase by the amount $y\Delta Ce$ (where y is the income tax rate), and the total benefit is $\Delta Ce\ (1 - y)$.

The term $y\Delta D$ recognizes the fact that the capital investment of the firm has increased, so depreciation expenses have also increased by ΔD. Hence the stated profits of the firm have decreased and tax payments diminished by the amount $y\Delta D$. Liberalized or accelerated depreciation allows an initial write-off of nearly double the straight line expense for long-term investments, and this method is often used by businesses to reduce their stated profit in the near term. In this analysis we use linear depreciation, which is also widely employed.

ITCc, the investment tax credit due to conservation, is in addition to the standard investment tax credit, ITCs; but these are received only in the initial period.

Not included in this analysis is any tax shield arising from the source of funds. In general, the particular financing arrangements in a company should be factored into the analysis as appropriate; the installation would probably be funded with a mixture of debt and equity, and to the extent that the investment is funded by debt, interest payments can be expensed.

In the example used in the text (a $10,000 expenditure which reduces energy costs by $2,000 in the first year) the cash flows for the lifetime of the investment are as follows:

Year	ITC Tax Credit	$\Delta Ce(1 - y)$ Energy Saving	$y\Delta D$ Depreciation	Cj Total
1	2000	1000	500	3500
2		1100	500	1600
3		1210	500	1710
4		1331	500	1831
5		1464	500	1964
6		1610	500	2110
7		1771	500	2271
8		1949	500	2449
9		2144	500	2644
10		2358	500	2858

high incomes and that they have tended to live at higher temperatures after insulating than before.

Other examples can also be invoked to support the notion that, with energy prices constant, a tax credit or a subsidy aimed at lowering the price of capital relative to energy may be used by consumers to increase their standard of living rather than to reduce energy consumption *per se*. The real incentive for conservation investment comes from the expectation of a loss of income due to rising energy prices.

This situation of rising prices has in fact prevailed since 1973, and consumers have been responding to higher prices by installing insulation and otherwise weatherproofing their homes; sales of insulation material, for example, have tripled since 1973.

To the extent that it affects investment decisions, the conservation investment tax credit will further stimulate demand for insulation, storm windows, improved burners in furnaces, and so on. In the short term, this new component of demand will move prices on such materials still further upward.

The normal response by manufacturers to such a market expansion would be to increase production facilities and bring more products onto the market. But what will happen if — as now proposed — the tax credit is short term, and known to be so? If the manufacturer cannot increase his production and distribution facilities within the period when the tax credit is available, he confronts the risk that, when the tax credit is removed, demand for the product may drop and he will be bringing unneeded new production to a contracting market. Sensing this risk, the manufacturer may opt for a partial expansion, and maintain his high price. In this case — which may very well prevail if present investment tax credit proposals are enacted — investment tax credit benefits will be effectively passed *through* the homeowner or business to the manufacturer. It would seem essential that, to be effective, the tax credit must be available for a sufficient time to enable production facility expansion to be completed, and the market to adjust accordingly.

Price with Market and Society in Conflict

So we come to consider the other major economic strategy in conservation — the pricing of energy itself, particularly oil and gas, to encourage the substitution of capital and labor and to reduce demand for fuels.

If the price of a commodity goes up because of increasing demand or decreasing supply, consumers generally respond by using less of the commodity. The classic microeconomic "income and substitution" effect takes place.

Suppose the price of energy rises, with gradual substitution of capital or labor. Two effects would operate. In the short run, less energy would be used simply because effective income has dropped; this is the income effect. In the long run, this short-term reduction in consumption will be consolidated by homeowners who make new capital investment — in insulation, for example, or in more energy-efficient automobiles; this is the substitution effect, which comes into play as the capital stock is changed. Some of these changes can be made fairly quickly; others will await the retirement of old capital stock and its replacement by more energy-efficient devices. There will also be technological change to bring new devices to the marketplace, which will enhance the possibilities for substitution.

There is ample evidence that this process was taking place before the advent of the National Energy Plan, motivated simply by the rapidly rising price of energy relative to other factors which has occurred since 1973. This was the beginning of an unprecedented transformation in the supply and cost of energy, the marginal price suddenly becoming higher than average price (*see "Energy: Policymaking in a New Reality," by Ben C. Ball, October/November, 1977, pp. 48-51*) leading to an inexorable (though occasionally faltering) upward march of energy prices.

If higher prices are inevitable, why should we be interested in taxing energy and artificially manipulating the price to be higher than would otherwise prevail? The main reason is to try to control the rate of price change rather than wait until actual scarcity suddenly takes command. The fear in the federal government is that the supply curve will exhibit sharply escalating price beyond 1990 because of the rapid consumption of oil, the time lag in the market's response to the increasing cost of "new" oil as "old" oil is consumed, and the long lead times required to bring in new technologies.

In contrast to this, it is the will of Congress to hold energy prices down in order to give the public the benefit of the relatively lower price of domestic production compared to imports at a time when there is no apparent scarcity. This has special appeal because rising energy price has a regressive effect; it hits poorer people harder. If domestic oil were sold at the price of imported oil, domestic producers would reap large profits, although taxes could be used to equalize these prices, and the government would then collect. Over the past years it has been desired to prevent these eventualities; now the National Energy Plan proposes that the latter become the new policy, apparently moving us toward a concept of pricing oil at its "replacement" rather than even at its marginal cost.

To understand the distinction, suppose that oil is priced simply at the marginal cost of primary and secondary re-

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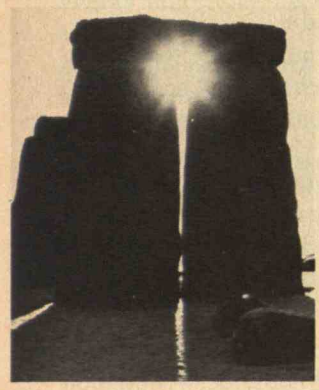

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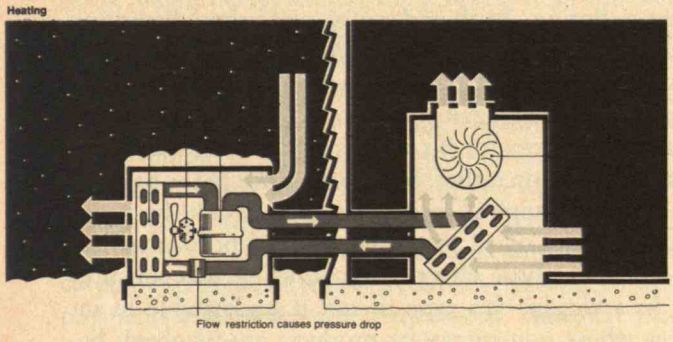

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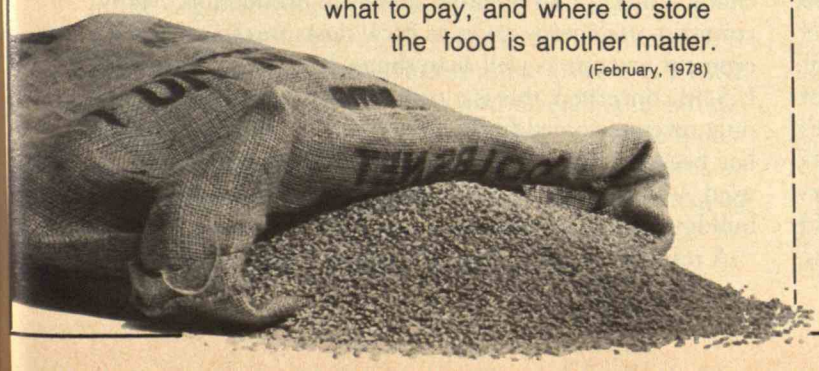

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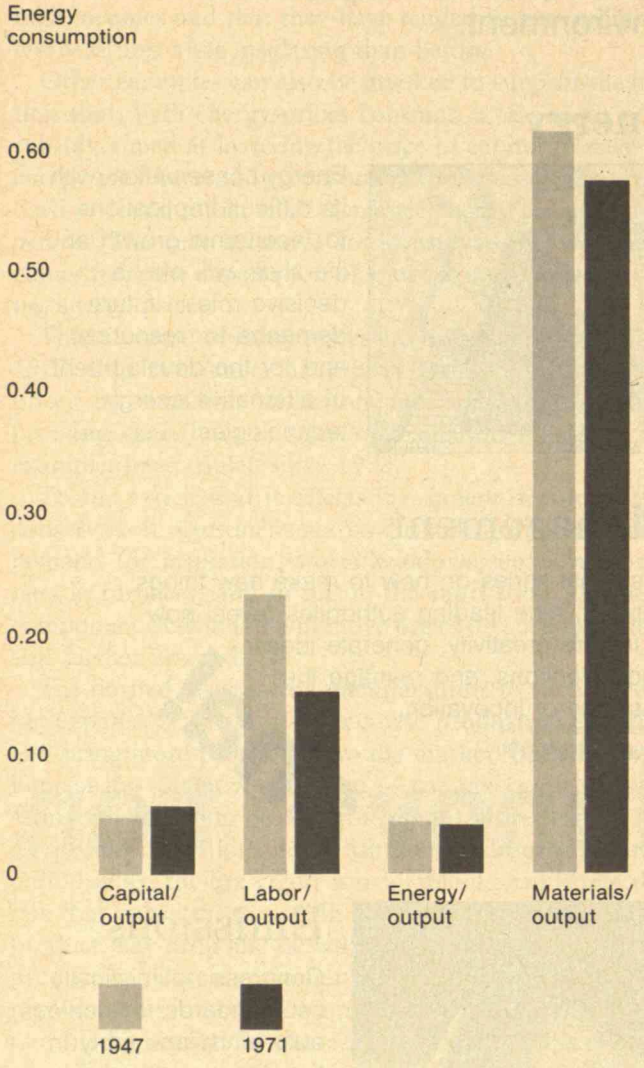


Changes in the proportions of capital, labor, energy, and materials used in U.S. manufacturing in 1947 and 1971. Throughout this period government policies encouraged capital investments, with the result that machines were increasingly substituted for labor. Energy prices were low and declining, and energy consumption per unit of output remained essentially constant.

covery. As more expensive recovery methods become necessary to satisfy the demand, the price will begin to rise and will continue to do so until synthetic fuel technologies become competitive. But suppose now that the depletion rate for crude oil is faster than the rate of introduction of synthetic fuel, due to the long lead times for developing synthetic technology and building plants to use it. Then price will rise rapidly as we confront scarcity, and it will "overshoot" the level at which it should have stabilized if the lead times for the synthetic technologies had been allowed for.

There are two ways to prevent this phenomenon. The first is to subsidize the new technology to make it appear cheaper than it really is. The second is to raise price artificially through taxes so that the new technologies are encouraged through the market mechanism. The inevitable price rise is thus achieved without overshoot or serious market distortion.

Of these alternatives, taxes have the advantages of promoting economic efficiency, because they encourage all technologies and alternatives to be brought onto the market. If some conservation strategy or unexpected energy resource becomes competitive during the phasing-in period, it will automatically attain a market share and the demand for other energy resources will be reduced. This would not have happened if the alternative resources themselves had been subsidized, or if oil had not been taxed at its "replacement" cost.

There are three main types of taxes on energy — general taxes, product taxes, and tariffs. A fourth type of tax, on machines or appliances, is proxy for an energy tax. Two of these — the product tax and the equipment tax — were proposed in the National Energy Plan.

The most important *product tax* in many countries is the gasoline tax. The private automobile is a very heavy user of fuel, and many externalities — such as atmospheric pollution, death and injury, and urban disruption — are associated with its use. Many countries have added taxes to control these external costs or even help recover revenue to be used against them.

A *general energy* (or B.t.u.) tax would be based on the gross consumption rather than on the price of the particular product. If applied to oil, the effect would be to increase the price of all petroleum-derived products; thus such a tax has little effect in encouraging fuel substitution. In addition, this type of tax is undesirable in instances where non-energy by-products are involved; because of the use of natural gas in products such as fertilizers, for example, complicated exceptions would probably accompany any general tax. The wellhead tax on oil is in fact such a general tax because it increases the price of all petroleum products.

The third form of energy tax is a *tariff*, which has the characteristic of stimulating domestic production. Many countries use energy taxes as fiscal measures to raise government revenue as well as to shape demand. As far as the U.S. in concerned, this is a controversial practice, and the only revenue gained from energy taxes to date in the U.S. has been used directly to support the way the energy is used — for example, the limited gasoline tax used for building and maintaining roads.

A result of the U.S. taxation pattern has been a prepon-

derance of heavy vehicles on the roads compared to the light, fuel-efficient cars of Europe. The traditional role of energy taxes continues to be more politically acceptable in the U.S. Thus we choose to regulate people out of big cars, using mandatory fuel efficiency standards, instead of taxing them out.

Product taxes, since they are selective on fuel type, encourage switching away from one fuel to another. Thus the National Energy Plan proposes this device extensively to tax industrial oil and gas in order to stimulate the switch to coal.

Conservation as a Social and Economic Opportunity

Just as the four inputs — capital, energy, labor, and materials — are intertwined, so are energy prices woven into the economy as a whole. Although energy itself accounts for only 4 per cent of U.S. gross national product, the effect of energy prices is pervasive. Rising energy prices mean that general inflation will be hastened, and particularly that poorer people will be hit the most. Thus when we adopt policies by which energy prices are increased — as we inevitably must — we must pay diligent attention to the economic effects, and we must take pains especially to assess the social and welfare effects.

As we have noted, direct taxes have the advantage of being manipulable, and the big problem is setting them at the correct level to achieve the desired result. We know that increasing the real prices of energy will raise the costs of production and tend to stifle economic growth. But the effect of the taxes is very difficult to quantify. So taxes on energy should be gradually phased in over a long period, to avoid as much as possible disruption of the economy.

Because energy price increases and taxes will be regressive, their social and welfare effects must be especially carefully studied and monitored, with overhaul of welfare payments undertaken where necessary. Those on fixed or low incomes who use small but necessary amounts of energy should not be subject to drastic loss of income. Devices such as energy stamps are typical of proposals to balance the effects of deregulation or taxation of natural gas and oil.

For reasons such as cited in the previous several paragraphs, energy conservation has sometimes been viewed in the negative context of restrictions on activities or in economic growth. In fact, the reverse can be the case. It is clear that effective conservation must involve extensive research and development, new and diversified manufacturing processes, and a large, new labor-intensive industry. It must also involve economic ingenuity in choosing the right investment in new processes and in managing existing supplies. No one can fault either of these as inputs of a growing, strengthening economy.

Conservation Response in the Residential Sector

A homeowner seeking to understand his potential savings through conservation would first complete an energy audit of his house, and his calculation would look something like the following.

Suppose the house area is 1,200 square feet, and it is located in the Boston suburban climate requiring 6,500 degree-days per year of heating. The homeowner is considering six inches of cellulose insulation in the roof at a cost of $400. (The walls should also be "audited.") The only formula he needs to know relates the "R value," or quality index of the insulation, to the climate and size of roof; it states that 1/R is equal to the number of B.t.u.s transmitted per square foot per hour, for every degree Fahrenheit of temperature difference between the two sides of the surface.

The "surface transmittance" in B.t.u./year is defined as 1/R times the number of degree-hours per year times the square feet of surface; in the example, the values are:

	Without Insulation	With Insulation
R	5	35
1/R	0.2	0.0286
Surface transmittance	37.4×10^6	5.35×10^6
Savings (B.t.u./year)		32×10^6

The price of one million B.t.u. delivered is approximately $3.50, and if the furnace is 85 per cent efficient this is equivalent to $4.12. The savings per year are $132. — *J.B.*

Further Readings

Engineering and Econometric Approaches to Industrial Energy Conservation and Capital Formation: A Reconciliation, by E. R. Berndt and D. O. Wood. Cambridge, Mass.: M.I.T. Energy Laboratory, Working Paper MIT-EL 77-040WP, November, 1977.

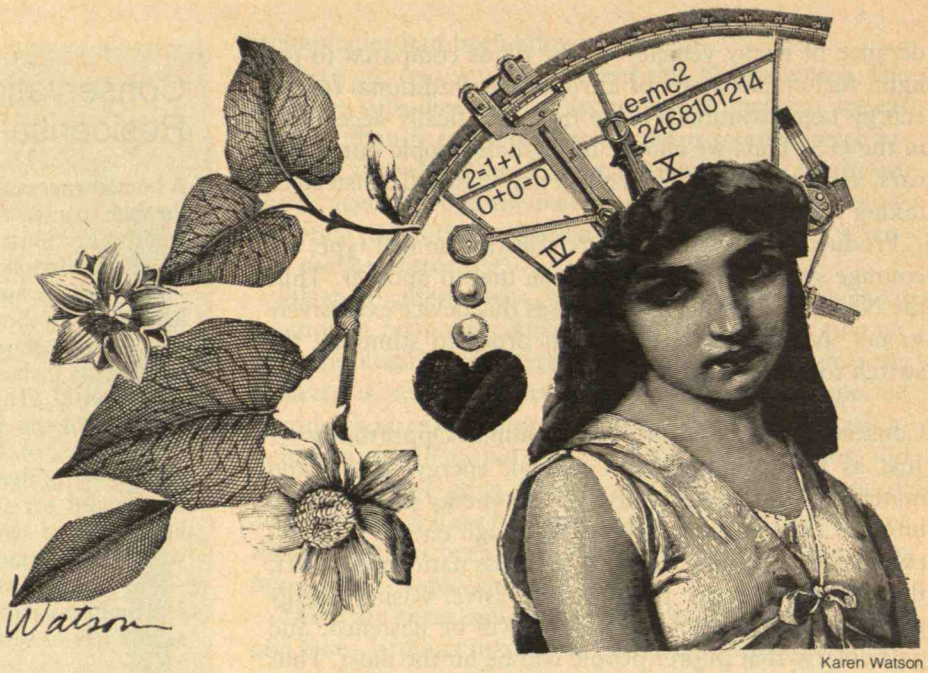
New England Energy Policy Alternatives. Boston, Mass.: Massachusetts Energy Office, 1977.

This paper was written while **John F. Boshier** was in the U.S. on a Harkness Fellowship funded by the Commonwealth Fund of New York; his work under the fellowship included several months with the M.I.T. Energy Laboratory's Energy Policy Group and two months as consultant to the Assistant Secretary for Policy in the Department of Energy, Washington. Before taking the Harkness Fellowship, Mr. Boshier was Senior Engineer in the New Zealand Electricity Department; he studied electrical power systems engineering at the University of Canterbury, Christ Church, New Zealand. He returned to New Zealand at the end of the summer to form a Policy Group for that nation's new Ministry of Energy. Mr. Boshier acknowledges with appreciation the assistance of David O. Wood and other members of the M.I.T. Energy Policy Group in the studies leading up to, and in the preparation of, this article.

Approaching Mathematics from Zero

Number Words and Number Symbols: A Cultural History of Numbers
Karl Menninger, translated by Paul Broneer
Cambridge, Mass.: The M.I.T. Press, 1977, 480 pp.; $9.95

Reviewed by Joan Baum



Karen Watson

Not long ago, I would have hazarded that "latus rectum" was a disease and "integration" conjured images of busing to distant schools. Natural enough. I am an English teacher. But the "functions" I now attend are not just social, and my only "eccentricity" is a formula for the ellipse. For the last year and a half I have been studying math. ("Latus rectum" is the chord perpendicular to the principal axis that passes through the focus; "function" describes the relation between sets; and degrees of "eccentricity" define the different conic sections. Understandably, mathematicians will complain that these definitions approach zero.)

I more than failed the test of C.P. Snow. He had challenged scientists to recount any Shakespearean plot and humanists to recite the second law of thermodynamics. I could barely do the first. Embarrassed by Lionel Trilling's assertion that the dominant mode of the age was unavailable to most humanists, uneasy at the decline of enrollment in courses in literature, and edgy at accusations that the humanities were powerless to effect moral change (Goebbels, it has been said, loved art); I began a campaign to bridge the cultural gap. I instituted a course in writing for science and technology, attended lectures, and read as much as I could. But my study was disorganized and it soon became clear that if I wanted seriously to study the subjects of science, I would first have to study its language — math.

Mystic Brotherhood of Numbers

The move to take a first course in geometry and algebra struck some of my colleagues as an irrational number. My reach, not to mention my grasp, seemed clearly hyperbolic. After all, I was a typical (female) liberal arts graduate: extra language courses in college liberated me from physics and chemistry; I had blundered my way through math, memorizing in agony what I did not understand. There was no reason to think 20 years later that pain and anxiety would not return. They did.

I became embarrassed when I misperceived spatial relationships that were obvious to some of my classmates whom I would teach an hour later in the English class; mortified when I made dumb arithmetic mistakes; humiliated when I forgot formulae one month after I had understood a proof; and manically high when I managed to calculate a complicated problem that walked in chicken tracks across my notebook. But I completed squares, survived the course, and decided to try trigonometry and calculus. Only vaguely did I begin to sense that mathematical language was pulling me in; and that from the world's only universal written language, I had slowly begun to gain a deeper understanding of my own language.

Without realizing how often, I began to introduce my math class to etymologies of mathematical words and to recommend essays by Brownowski, Asimov, and Kline. My curiosity about the mathematician's joy when he describes his world, led me to wonder about a mystic brotherhood of numbers that united the Pythagoreans. Soon, other students joined in, asking why numerals were discovered by the Hindus, and why it was Arabic culture that introduced modern math into the West. That year I was teaching Wordsworth, and I followed him gladly in *The Prelude* from childhood days to Cambridge where he was captivated by its statue of Newton: "The marble index of a mind for ever/Voyaging through strange seas of Thought, alone." But how was it, I wondered, that I knew nothing about the kingdom of Wordsworth's contemporary, Karl Friedrich Gauss, "the prince of mathematicians"? Why did I know only the *Rubáiyát* of Omar Khayyam and not his Standard Algebra, especially since "rubai" was the number word for four?

So when I saw Karl Menninger's great treatise on linguistics and math, I felt that I had been guided toward it by some mysterious and axiomatic principle.

Roots of Numerical Language

Dense, fact-filled, meticulous in its considerations of history, linguistics, economics, anthropology, comparative philology, geography, literature, art, and Menninger's original field, math, *Number Words and Number Symbols* is significantly addressed to the "lover" of intellectual and cultural history. At its head is the thesis that number language and numerals have independent histories (written number symbols are not mere representations of number words, which came first). At its heart is an "interweaving" of numbers and human life, a charting of the "eternal stream" of knowledge and number, humanity at the banks. Menninger writes: "A people's number sequence is not a system created fresh out of the pure workings of the mind; it is rooted in the same soil as the people. Like culture itself, it grows up slowly over the millenia, and even in its mature form it reveals the history of its

people through the successive deposits of the passing years."

There is enormous scholarship here, from the earliest counting words for the digits, to the recognized adoption in the sixteenth century of the Indian-Arabic numerals and place-value system of notation. Menninger conveys his sense of "pleasure," "delight," and poetic "joy" in his research. The intrigue comes clear when he writes: "They pass by us [the number words], mute, like alien slaves valued only for their services, and we do not dignify them by inquiring into their 'person' and 'homeland.' "

Courteously, Menninger allows for interrupted reading: chapters contain frequent summary paragraphs and internal references. The two main parts — Number Sequence and Number Language, and Written Numerals and Computation — can be read as independent treatises. Indeed, reading too much at once might induce the number word for half a skull: (*he*) *mi-krania,* or migraine. But the lore is fascinating: the fast-changing semantics of number words whose linguistic forms remain the same; the evidence that number words originally had both graphic and figurative meaning; the history of some general words that hide numerical origin ("quarantine" refers to forty days' detention evolved from its importance in the Bible and to Mediterranean traders); the psychological importance of some number concepts over others ("two," "three," "ten," "twelve," "hundred," and the long-slumbering "zero" are key words); the growth of the idea of infinite progression, beginning with the number "three," which separated the personal world from the "other" or the "many"; the expansion of the number sequence by means of supplementary quantities which moved counting, ordering, and grouping into base-systems; the reasons some number words became general adjectives (myriad), thus liberating number words from their dependency on the empirical world; and finally, the great westward migration, beginning in the seventh century, of Indian notation through Arabic culture, into the West.

Menninger, in mapping this sometimes anomalous, paradoxical, and mysterious adventure, will surprise those who have been disposed to think of mathematics as precise and bone-dry. Here are Romans, masters of great systems and abstractions, of vast flexible empires of verbal number words; who, without reason, stick to a crude alphabet system of notation that is as confusing as it is cumbersome. Here are so-called nonsense rhymes, like "eeny, meeney, miney, mo," with linguistic affinities in other tongues, masking concepts no longer known. And here is the western medieval mind, fearing the zero as devil's work and schizophrenically doing complex calculations on a counting board while still writing numerals in a limiting notation form.

As for the Indian discovery of numerals and the concept of decimal place position (03 instead of 30 for three), Menninger has no explanation other than to declare the Brahmi "gift" for numbers, reminiscent of Pythagoras who, when he finally proved the right tri-angle formula, offered 100 oxen to the muses in thanks for the inspiration. In the history, as opposed to the practice of mathematics, right answers are not necessary or even revealing.

Crossing the Cultural Divide

Although Menninger's stated purpose is interdisciplinary, the main benefactors of his book will be the humanists, whose attempts to cross the cultural divide may require a greater effort due to long intimidation by technical vocabulary. But *Number Words and Number Symbols* shows that the meta-language of math is derived from the same sources as ordinary language and that it developed according to the same linguistic principles. "Algebra," for example, an Arabic word ("al. jabr") meaning "restoration," comes from the title of an early text: *Hisab al. jabr w'al. muqabala* — the book of restorations and equalizations — which is a fair explanation of the method of solving equations in that system.

What Menninger demonstrates is that the development of number words and symbols was far from ordered and precise. The human endeavor to establish a universal system of notation was full of what constitutes all intellectual pursuits: convenience, accident, failure, and paradox. The shortest distance between two points may be a straight line, but that is not the direction of cultural history. This valuable "humanizing" lesson about math might have helped me, years ago, to relax and understand mathematics as an expression of the creative as well as of the critical faculties in man.

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Hearts and Minds: The Psychology and Politics of Cold War

Shattered Peace: The Origins of the Cold War and the National Security State
Daniel Yergin
Houghton Mifflin, 1977; x + 526 pp., $15.00

Reviewed by Robert Jervis

The Cold War and its origins remain endlessly fascinating and have provoked a steady stream of books. A few are based on newly discovered or de-classified documents, but this is not a necessary condition for an interesting study.

The increasing size and complexity of governments have produced archives so large that no one can hope to read through them. The best of archivists cannot even know the location of all important documents. And even if someone could read and remember the papers, the important questions would remain difficult. Scholars still vigorously debate the causes of the two World Wars even though all German and most British documents are available. We would all love to read the Kremlin's archives; they would surely solve a number of intriguing puzzles. But even they would not provide a definitive answer to the general questions of what factors contributed most to the conflict, whether different American behavior could have called forth different Soviet responses, what opportunities the U.S. missed for advancing American values and/or reaching settlements in the common interest of both superpowers.

Without doing too much injustice to the scholarship in the field, debate on these issues can be grouped into three schools of thought. The first, or "conventional," school was largely unchallenged until the Vietnam War seized attention in the mid-1960s. It held that Russia was highly expansionist, that U.S. policy during and shortly after World War II was much too idealistic and unrealistic, that leaders and the public failed to appreciate the role of power in international politics in general and the need to threaten to use force against the Soviet Union in particular, and that had the U.S. been quicker to take a tougher position the world would have been freer and safer. All this is turned on its head by the revisionists who claim that the U.S., and not the U.S.S.R., was expansionist, failed to respect agreements

and the other side's legitimate interests, paid attention only to power, and pursued its interests (interpreted in economic terms) with great realism. Russia was reasonable, these critics say; had the U.S. been willing to tolerate political and economic diversity in the world, cooperative arrangements could have been established.

Daniel Yergin's *Shattered Peace* is a persuasive contribution to the third school. (Part of the reason why it is persuasive is that it is so well-written. Dean Acheson once found himself readily accepting the arguments of one of his subordinates, a skilled writer. To avoid being swayed by such irrelevancies he had someone else re-write the memoes to conform to the usual dry, State Department prose.) For a growing number of scholars, the most important cause of the Cold War lies, as the revisionists argue, at the door of the U.S. — but as a result of its politics and ideology, not its capitalist economy. America's public, and, to a lesser extent, its leaders, were imbued with Wilsonian liberalism. Given the unique American style of foreign policy stressed by the first school, Dr. Yergin and others argue that in the 1940s the U.S. did not see the world or its own interests realistically. Throughout most of the country's history, Americans have felt that international politics as practiced by the European states was short-sighted, dangerous, and immoral. Unless the stakes were terribly high, we simply should not participate. We had to fight World War II to prevent world domination. But lacking such a menace, continued participation could be justified only by the hope of transforming world politics and establishing a regime based on justice rather than power. To compromise, to trade the fates of helpless peoples, to countenance spheres of influence, was anathema. (This did not, of course, prevent the U.S. from maintaining its own sphere in Latin America or minimizing Soviet influence in Japan and Europe.) But Averell Harriman saw the problem: "I am afraid that Stalin does not and never will fully understand our interest in Poland as a matter of principle. He is a realist in his actions, and it is hard for him to appreciate our faith in abstract principles."

Riga versus Yalta

Neither side understood the other. In retrospect, Russia probably had more right to be puzzled. What rules was the U.S. playing by? The Soviet Union withdrew its troops from Europe but still demanded a say there. It maintained its security interests in East Europe but still insisted on free elections which would undermine those interests. It talked of justice and principles but always applied those standards so as to expand its power. In April, 1946, the new American ambassador to Moscow began his interview with Stalin by asking, "What does the Soviet Union want, and how far is Russia going to go?" The Russians had reason to ask the same question.

Even before this question was raised openly, the American specialists on Russia thought they knew the answer. The members of this group, which included George Kennan, Charles Bohlen, and Loy Henderson, were all trained in the Foreign Service during the inter-war period and came to accept what Dr. Yergin calls the "Riga axioms" (for the Latvian listening post where these diplomats spent many of their formative years). This view held that the Soviets were ideologically driven expansionists who could not be trusted to keep their word and who would not rest so long as capitalist states existed. During World War II, however, another answer, embodied in the "Yalta axioms," held sway. President Roosevelt and others believed they would do business with the Russians, that peace could be established on the basis of great-power cooperation. Roosevelt realized, Dr. Yergin argues, that such cooperation required important concessions to the Soviets — particularly acquiescence to their control of East Europe. (In passing I should note that Dr. Yergin's F.D.R. seems much more consistent and less confused than I think he was.) The problem for Roosevelt was not the Russians, but the American public who would not accept a realistic policy contrary to Wilsonianism. And instead of trying to educate the public, F.D.R. misled it. "With the Russians, he talked of a Great Power consortium, based on the realities of international politics. At home, he continued to try to obscure this basic program in the idealistic Wilsonian language," Dr. Yergin concludes. But for this policy to succeed in the long run required both Soviet cooperation and F.D.R.'s incomparable political management.

With the death of the President, the Yalta axioms lost their most powerful proponent. President Truman knew little of foreign affairs and most of those around him opposed granting Russia a sphere in East Europe and were skeptical of the chances of cooperation with her. Many people in both the foreign policy élite and the wider public believed that Soviet activities in the countries she occupied were highly aggressive. They rejected the parallel to American policies in West Europe and Japan and denied that Soviet security required the creation of satellites. Not understanding the nature of international politics, they took traditional but unpleasant behavior as evidence not of limited conflict-of-interest but as extreme aggressiveness. Those few leaders who wanted to continue F.D.R.'s policy (e.g. Secretary of State Byrnes) lacked the necessary public and élite support. To survive at home they had to support foolish policies abroad.

Squaring Off

This explanation is certainly plausible. (Although it should be noted that if it is correct it undercuts Dr. Yergin's argument that belief in the Riga axioms were a major contributor to American foreign policy: domestic politics presumably would have produced the same outcome no matter what the Foreign Service Officers believed.) Given the nature of historical explanations and historical evidence, we cannot hope for anything like proof. But a few points in favor of other explanations can be made.

First, it is far from clear that a more realistic U.S. policy would have led to a more cooperative Soviet policy. The Yalta axioms may have been based on false premises. It was of course reasonable for Russia to demand that the East European states not menace her security, but was it reasonable for her to demand such rigid conformity to Russia's internal and foreign policies? Could someone as ruthless and as paranoid as Stalin have been a reliable partner in foreign policy? Even if advocates of the Riga axioms overestimated the importance of Communist ideology, were those doctrines sufficiently potent to disrupt Roosevelt's policy even if he had been able to implement it? Second, wouldn't a country that was not driven by Wilsonian liberalism also have considered Russia's actions aggressive? For example, although British leaders were much more "realistic" than American ones, their analysis of the Soviet Union seems (and we cannot be more definite until there are detailed studies on this point) to have been quite close to ours. Third, no matter what the regime or ideology of either the U.S. or Russia, conflict would have been difficult to avoid: they were the only two major powers in the world and could not help but threaten one another. They were, to use Raymond Aron's phrase, "enemies by position." Even had each shown more understanding and tolerance, it is not at all clear that their security requirements

would have been compatible. Given a normal amount of suspicions and ambitions, cooperation — while not precluded — probably could not have been expected. So as intriguing as the American world-view and domestic politics are, they may not have been the crucial variables.

Finally, we might lay greater stress on what Dr. Yergin notes in passing: the role of the Korean War. His book, like many others, concentrates on the late- and mid-1940s. Most of us think of these years as the height of the Cold War. But in fact many of the manifestations of this conflict appeared only after Korea. High American defense budgets, the transformation of N.A.T.O. into a real military force, the rearmament of Germany, the view of Communism as monolithic and Communist China as an enemy, the belief that Communist gains anywhere in the world were a menace to the vital interests of America — all these were a product of Korea. And if this conflict was caused by factors much more ephemeral than those normally associated with the origins of the Cold War, and if these results would not have been produced by any other events that were likely to occur, then much of the Cold War must be seen as more of an accident than we usually think.

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Coal and Conscience

The Rape of the Great Plains: Northwest America, Cattle and Coal
K. Ross Toole
Boston: Atlantic Monthly Press, 1976, ix + 271 pp.; $8.95

Reviewed by Michael O'Hare

The enormous low-sulfur coal reserves in the northern great plains are often cited to comfort us against incipient energy shortages. Unfortunately this optimism is unwarranted, as Mr. Toole argues here: the only cheap thing about western strip-mined coal is the short-term dollar cost of its extraction. Disastrous social and environmental consequences will follow exploitation of this resource. Already, what makes life worthwhile for many Indians, ranchers, and townsfolk of the Great Plains is either being sold or simply appropriated.

Blind Justice

The circles of impact and responsibility widen to infinity: having learned not to throw things "away" because there is no such place, we should understand that the environmental destruction of strip-mining in an arid landscape must in some way hurt us all. One of Mr. Toole's most troubling observations is the failure of sufferers and gainers to sort themselves geographically, by income or according to any other simple demographic dimension. Thus the crude tools by which government distinguishes those who will be affected by policy from those who will not are probably inequitable in application. The best our officials can do will appear to many as a blind justice slashing its way among the deserving and the innocent.

Nonetheless, we must do something. Mr. Toole wants us to meet our energy needs without exploiting western coal, but his own resource analysis suggests only that we can put it off a little longer. In the meantime, we can deep-mine eastern coal, or strip-mine in country where enough rain falls to allow real reclamation.

As we come to recognize that the most far-away places border on our own backyards, we should also reach a better understanding of other spurious absolutes: "priceless" and "need," for example. It's much more useful to think of what would happen if we learned to make do with less energy than to say we "need" alternative sources. And little guidance is won by declaring the current condition of any natural environment to be "priceless." While we pray for effective conservation strategies and practical solar collectors, we are also going to be making painful choices; we will probably make them better if we make them explicitly, rather than by default or in thrall to some rigid ideology.

Who Owns the Coal?

The framework for decision is unfortunately still shaky. For example, as we sort our way through the problems Mr. Toole poses, we regularly turn up questions which at bottom concern property rights. I have proposed that communities threatened with disagreeable new enterprises should be allowed to estimate and sell their amenity, demanding a price that makes them feel — at least collectively — that they are as well off after development as before. But this strategy makes sense only if the local citizens can be said to "own" the conditions of life in their town, as well as the town itself. The assumption is reasonable, but the principal generalizes uncertainly. And to jump into the deepest part of the morass, who owns the coal?

A court would answer the question easily by looking at a written history of deeds and mineral leases, but this solution is either inconsistent with such existing laws as severance taxes and reclamation requirements, or a Portian sophistry. If the state can demand a fraction of the coal's value as it is mined, then its whole population is exerting a partial right of ownership. If the "owner" can't disturb the local economy or the surface of the earth when he extracts the coal, then he doesn't own it any more than Shylock owned a pound of Antonio's flesh. Other claims can be identified: people froze to death in the East

and Midwest last winter, and "ownership" of energy may not much longer include the right to withhold it from use — or even to demand a price which includes an economic rent.

The wise policymaker will have to pick his way carefully among existing property rights and those which, latent until now, may be established by legislation or public outrage. This latter variety includes national, public, ownership of the natural environment, local residents' ownership of a predictably stable quality of life, energy consumers' rights to this same quality of life (which may depend on a steady flow of coal), and Indian rights to a prosperous future which serves their community values however they may differ from European conventions.

This is not country in which to navigate without native guides. And the value of a study like Mr. Toole's is the freedom the author assumes — as an historian and an affected party — not to propose a solution or even to resolve the conflicts he describes. Those of us who claim to prescribe policy according to the principles of social science have regularly shown that, without informed voices of conscience, we will solve the wrong problem — or trample the right one underfoot.

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Corporate Capitalism

America by Design: Science, Technology, and the Rise of Corporate Capitalism
David F. Noble
New York: Alfred A. Knopf, 1977, 384 pp. $12.95

Reviewed by Jeffrey Lant

Has "modern technology in America been tamed? Has the most potent revolution in social production since the invention of agriculture become merely a means to corporate ends, a vehicle of capitalist domination?" David Noble, a radical historian, poses these questions and suggests disquieting answers.

"Each major scientific advance, while appearing to presage an entirely new order, attests rather to the vigor and resilience of the old order that produced it." According to Dr. Noble, ours is "a remarkably dynamic society that goes nowhere."

How did this state of affairs come about? Dr. Noble, now Mellon Fellow in the Humanities and Engineering at M.I.T., places the blame on the shoulders of the professional engineer, who has been less concerned with bringing humanity to the workplace than with amassing corporate profits through managerial control and labor-saving devices.

Several questions immediately follow: where did these engineers come from, how have they managed to effect such control, and is it worthwhile and — one ought to ask — even possible to do anything about it?

In answering the first two of these questions, Dr. Noble's arguments are thoroughly and persuasively, documented. The engineer was intended to link the business community to developments in 19th century science in order to minimize the many hazards which bedevilled the progress of an idea from birth to assembly line. Or as Dugald Jackson, past Chairman of M.I.T.'s Electrical Engineering Department, put it, the engineer should connect "the monastery of science and the secular world of business." But once the link was established, Dr. Noble believes that the dictates of business proved irresistible, and the goals of pure science were undermined as a result.

Henry Towne, a Victorian engineer, told a group of Purdue University students towards the end of the last century, "The dollar is the final term in every engineering equation." Nearly a century later A. A. Potter, who Dr. Noble terms "the dean of American deans of engineering," said, "Whatever the numerator in an engineering equation, the denominator is always the dollar mark."

So long as this sentiment remains current (and it still does, of course), the activities of Dr. Jackson's monastery will continue to be circumscribed by what is acceptable to business. And what is acceptable — indeed crucial — to business has always been, first and foremost, preserving its own profitmaking system. Thus new technology either had to be made to serve the corporation, or it had at least to be contained so as not to jeopardize the corporation's profitmaking activities.

Several things had to take place so that this premier corporate end could be attained: scientific and industrial standardization had to be accomplished; patent law reform and patent monopoly had to occur; industrial and university research had to be arranged in a manner congenial to business interests; and, of course, those very important personages, the engineers, had to be educated in sufficient numbers and molded in such a way that they would be useful to the corporation. Useful and unquestioning.

All this American corporations managed to effect, though their consolidation of these ends was by no means effortless or inevitable. Fortunately, Dr. Noble turns his attention to each strategy so that we know why and how it was all done.

Take the patent process, for instance. Abraham Lincoln said that "the patent system added the fuel of interest to the power of genius"; words inscribed above the doors of the new Patent Office in 1932. Dr. Noble demonstrates that long before this impressive phrase was mounted, it had ceased to bear much relation to the true circumstances of those who had ideas to patent. As E.F.W. Alexanderson, a Swedish immigrant who became one of General Electric's leading research engineers, put it: "The patent system was established to protect the lone inventor. In this it has not succeeded . . . The patent system protects the institutions which favor invention."

The reasons why these "institutions" — read corporations — worked so hard to establish patent monopolies are not hard to guess. Edward J. Prindle, a turn-of-the-century mechanical engineer and patent lawyer, wrote, "Patents are the best and most effective means of controlling competition. They occasionally give absolute command of the market, enabling their owner to name the price without regard to cost of production."

Following Mr. Prindle's impeccable logic, corporations moved fast to create research organizations of such effectiveness that independent work was no longer viable, organizations which succeeded by squelching individual initiative and substituting a team mentality.

At the same time, corporate executives worked to circumvent the antitrust laws that could have mitigated the effects of their monopolies by making intercorporate agreements and by reforming the patent system in the corporate favor. These maneuvers have made independent invention nearly impossible and assured that ideas which are not to corporate liking or benefit will languish.

One witness testified before the House Committee on Patents in the 74th Congress, "The greater the contribution, the more certain is it to be denied recognition by the entrenched corporations and their servile laboratory staffs. And the lack of

such recognition . . . [in part] explains the shameful spectacle of every single one of the world's great inventions having been forced to be idle until outside competition had forced their adoption despite the cunning and conspiracy of the great corporations in that field. . ."

By the same token, once the patent situation had been streamlined to corporate advantage, business executives turned their attention to maintaining the flow of patentable ideas at minimum cost: corporate influence on both universities and the government followed as a matter of course.

Finally, once the system had been organized (and again it must be stressed that the enterprise was neither clean nor inexorable), the engineers became even more important. With their technical skills and concern for profit, they could best manage the industrial process. The most significant observation of Dr. Noble's book may be the extent to which engineers have come to do so.

Having surveyed the degree to which capitalistic enterprise has subsumed science and technology, has contrived to make the patent system its own, has influenced and often determined the direction of most industrial research, and has succeeded in creating a race of technocrats who can make the existing system work but who will never be able to change it for the better, Dr. Noble is at a loss to resolve the problem. But the questions with which he leaves us are profound: What are our options? How do we achieve the more humane workplace Dr. Noble envisions? How can we repair a society in which a dominant class struggles "to extract labor from, and thus to control the lives of, the class beneath it"?

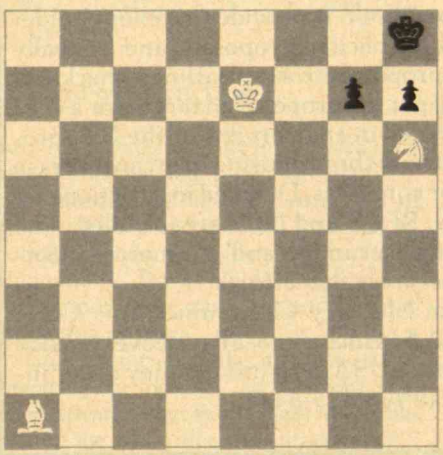
Dr. Jeffrey L. Lant is Coordinator of Student Services in the Evening College at Boston College. □

Help Allan Solve His Cocktail Party Puzzle

Allan J. Gottlieb studied mathematics at M.I.T. (S.B. 1967) and Brandeis (A.M. 1968, Ph.D. 1973); he is now Assistant Professor of Mathematics and Coordinator of Computer Activities in the Mathematics Department at York College of the City University of New York. Send problems, solutions, and comments to him at the Department of Mathematics, York College, Jamaica, N.Y., 11451.

This is a sad time for Puzzle Corner. Our most active participant, R. Robinson Rowe (M.I.T. '18), died on May 4. In his last letter to "Puzzle Corner" dated April 17, Mr. Rowe mentioned that he was "lying on my back 98 per cent of the time." Harry Nelson, the Editor of the *Journal of Recreational Mathematics*, forwarded a copy of Mr. Rowe's letter to *JRM* dated May 1. The letter was concluded by Edwin R. Rowe who told us of his father's death. This issue of "Puzzle Corner" is dedicated to his memory.

A/S 1 We begin this month with a novel chess problem from Abe Schwartz. White is to play and mate in three moves. Nothing unusual about that, but you are to show that White can mate in three moving either up the board or down.



A/S 2 Michael Auerback submitted the same problem that a York student sprung on a few of our faculty. The faculty liked it; what do you think? (Incidentally, Mr. Auerback edits *The Valchemist*, the magazine of the Connecticut Valley Section of The American Chemical Society.)
Recently Allan Gottlieb and his wife attended a cocktail party at York College at which there were four other married couples. Various introductions and handshakes took place. No one shook hands with him- or herself, or with his or her spouse, and no one shook hands with the same person more than once. When Allan asked everyone how many people they had shaken hands with, to his surprise each person gave him a different answer. How many hands did his wife shake?

A/S 3 Eric Jamin sends us a geometry problem which was part of the 17th International Mathematics Olympiad:
Given any triangle ABC, construct outside it the three triangles BCP, CAQ, and ABR such that

$\angle PBC = \angle CAW = 45°$,
$\angle BCP = \angle QCA = 30°$, and
$\angle ABR = \angle RAB = 15°$.

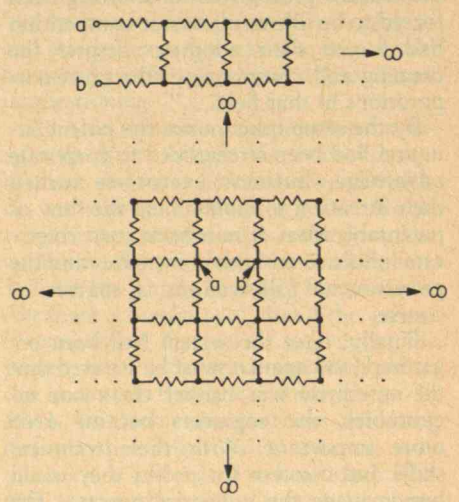
Show that $\angle QRP = 90°$ and that RQ = RP.

A/S 4 Consider the number 153. It turns out to be equal to the cubes of its digits — i.e., $153 = 1^3 + 5^3 + 3^3$. Find three other such numbers. This property can be extended to four-digit numbers — for example, $1634 = 1^4 + 6^4 + 3^4 + 4^4$. Find two other such four-digit numbers. In the same way, the property can be generalized for numbers of any size. Martin Gardner published a five-digit number of this type several years ago. Find a proof that there are an infinite number of such numbers, or else prove that only a finite number exist.

A/S 5 We close with a cryptarithmatic problem from Frank Rubin: Replace each letter by a unique decimal digit.

$$\begin{array}{cccc} & & H & E \\ \times & & I & S \\ \hline & H & U & B \\ & O & F & \\ \hline & L & A & B \end{array}$$

Speed Dept.
A/S SD1 and A/S SD2 Stephen Polloch claims that these two are speed problems in electrical engineering. Those of you who remember my exploits assembling hi-fi kits will understand that I am in no position to judge anything electrical. In both problems each resistor is 1 ohm and you are to find Rab.



Solutions
NS 11 Can any square matrix composed of just 0s and 1s have a determinant no greater than F_n (F for Fibbonacci), where F_n is defined by $F_1 = F_2 = 1$ and for n at least three $F_n = F_{n-1} + F_{n-2}$.

Jerry Griggs informs me that Herb Ryser has an article on this subject in the *Canadian Journal of Mathematics* 8 (1956) pp. 245-249. Although the exact upper bound is unknown, it is larger than Fn, as the following counterexample shows.

1 0 1 0 1 0 1
0 1 1 0 0 1 1
1 1 0 0 1 1 0
0 0 0 1 1 1 1
1 0 1 1 0 1 0
0 1 1 1 1 0 0
1 1 0 1 0 0 1

Harry Zaremba also responded and Richard Stanley submitted the following: Let f(n) be the largest determinant of an $n \times n$ matrix of $+1$s and -1s, and let g(n) be the largest determinant of an $n \times n$ matrix of 0s and 1s. If M is an $n \times n$ ± 1-matrix, then multiply rows and columns by ± 1 so that the first row and column contain all 1s. Now subtract the first row from the other rows and factor 2 out of all rows but the first. The last $n - 1$ rows and columns form a 0-1 matrix N with

$$\det M = \pm 2^{n-1} \det N.$$

This process of getting N from M can be reversed. It follows that

$$g(n) = 2^{-n} f(n + 1).$$

Hadamard's determinantal inequality

states that $f(n) \leq n^{n/2}$. Hence $g(n) \leq 2^{-n}(n+1)^{(n+1)/2}$. An $n \times n$ ± 1-matrix M is called a *Hadamard matrix* if

$$\det M = \pm n^{n/2}.$$

It is known that Hadamard matrices exist for infinitely many values of n — e.g., whenever n is a power of 2 or when $n - 1$ is a prime power and n is divisible by 4. (See M. Hall, Jr., *Combinatorial Theory*, p. 207). Hence, for infinitely many values of n,

$$g(n) = 2^{-n}(n+1)^{(n+1)/2}.$$

This is much larger than F_n. For any n one can show that g(n) is not much smaller than $2^{-n}(n+1)^{(n+1)/2}$.

It is interesting that even an "average" 0-1 matrix will have a large determinant (in absolute value). One can show that the average value of $(\det N)^2$, taken over all 2^{n^2} $n \times n$ 0-1 matrices N, is equal to $4^{-n}(n+1)!$ Thus there must be many N with

$$\det N \geq \sqrt{4^{-n}(n+1)!}$$

$$\sim \sqrt{2\pi}(2\sqrt{e})^{-n}\, n^{(n/2)+1},$$

which is much larger than F_n.

Your readers may be interested in trying to prove the following (difficult) result of Komlós. As $n \to \infty$, the percentage of $n \times n$ 0-1 matrices with determinant 0 approaches 0.

M/A 1 Given the following hands, and the bid of seven spades by South:

	♠— ♥A 10 8 6 ♦A K Q J ♣A J 10 7 5	
♠9 2 ♥Q 9 7 ♦7 6 4 3 2 ♣K Q 6		♠7 6 5 4 3 ♥K 5 4 3 2 ♦— ♣9 4 3
	♠A K Q J 10 8 ♥J ♦10 9 8 5 ♣8 2	

After the opening lead of the ♥Q, South has 12 tricks. Where will the 13th come from?

Many favorable comments about this problem were received. Also, many correct solutions. The following is from Frank Pollnow.

As in the case of many tricky bridge hands, the solution lies in "wasting" top honors. After taking the lead with the ♥A, declarer plays the ♥10 off the board, presumably East covers (or the 13th trick is thereby made) and South trumps with the ♠8. South then plays out the 5 trumps, discarding the four diamond honors in the dummy and a small club.

Next, South plays out the ♦10, ♦9, and ♦8, at which point West is hopelessly squeezed with only three cards remaining. If West has not retained a diamond and a heart, these tricks set up in the declarer's and dummy's hands, respectively, and together with the ♣A, secure the 13-trick contract.

If West retains a diamond and two clubs, the dummy's two remaining hearts comprise the 12th and 13th tricks. And if, of course, West retains one or less clubs, the contract is completed by cashing the three club honors on the board.

Also solved by Ronnie Rybstein, Glenn Brown, G. Holderness, Mike Bercher, Bo Jansen, John Lai and David Cochener, Steven Feldman, Rex Ingraham, Phyllis Grossberg, Mark Freundel, Jerry Grossman, Jacob Bergmann, John Rule, Edmund Chen, William Butler, Jerome Gordon, Edgar Rose, Douglas Van Patter, Gardner MacPherson, Sheldon Katz, Douglas Stark, Paul Horvitz, Steve Grant, James Shearer, David Olson, Michael Kay, Rudolph Evans, Edward Lynch, Eugene Biek, Emmet Duffy, and the proposer, Albert J. Fischer.

M/A 2 What is the smallest positive integer containing at least 1 million distinct proper factors? (The factors need not be prime; for example, 12 has four factors — 2, 3, 4, and 6.)

Many readers submitted solutions having the same order of magnitude (23) but two, Charles Rozier and Jacob Bergman, found answers a little smaller than anyone else. Those of you who enjoyed this one might try to find the smallest positive number with exactly one million proper factors. Mr. Rozier's solution follows:

As Gauss pointed out in *Disquisitiones Arithmeticae*, any integer can be factored into a unique set of n primes p_i with respective exponents e_i, and further, the number of distinct factors including 1 and the number N itself is given by

$$\prod_{i=1}^{n}(e_i + 1).$$

As implied by the example in the problem statement, 1 and N are not to count as factors among the required one million. So we seek

$$N = \prod_{i=1}^{n} p_i^{e_i}$$

where N is the minimum positive integer containing at least

$$F = \prod_{i=1}^{n}(e_i + 1) - 2 = 10^6 \text{ factors.} \qquad (1)$$

N will be minimum when log N is minimum. Consider minimizing log N as a function of any two exponents, say e_1 and e_2. If there is a pairwise minimum of log N, it will be found where the Jacobian is zero:

$$\begin{vmatrix} \frac{\delta \log N}{\delta e_1} & \frac{\delta \log N}{\delta e_2} \\ \frac{\delta F}{\delta e_1} & \frac{\delta F}{\delta e_2} \end{vmatrix} = 0, \text{ or}$$

$$\begin{vmatrix} \log p_1 & \log p_2 \\ \frac{F}{(e_1+1)} & \frac{F}{(e_2+1)} \end{vmatrix} = 0.$$

This leads to the conclusion that for any pair of exponents e_i and e_j, the minimum of N corresponds to the condition

$$(e_j + 1) = (e_i + 1)\frac{\log p_i}{\log p_j}. \qquad (2)$$

If a value is selected for n, the number of prime factors of N, the approximate values of e_1 through e_n can be calculated from (1) and (2):

$$(e_i + 1)^n \simeq (10^6 + 2)\frac{\prod_{j=1}^{n} \log p_j}{(\log p_i)^n}.$$

For example, if n = 2, the rounded values of e_1 and e_2 are 1258 and 793. But the rounding process in this instance results in a value for F less than 10^6, because $1259 \times 794 - 2 = 999644$. To increase F, either e_1 or e_2 could be increased by 1; however to minimize N it is expedient to decrease e_1 and increase e_2 by 1.

Then $e_1 = 1257$ and $e_2 = 794$, F = 1,000,108, and $N = 2^{1257} \cdot 3^{794} \simeq 1.694 \cdot 10^{757}$.

Using the same procedure, the values of n, e_i (i = 1, 2, 3 . . . n), N and F were determined and arranged in the tabulation at the top of the next column. It would appear from the table that N is a minimum for n = 12 or 13. However, again the round-off results in some values of F below 10^6. When these are adjusted upward, the minimum shifts to a higher value of n. Furthermore, some values of F are too large, so some of the e_i can be judiciously reduced to minimize N. The least value of N meeting the conditions that I could find by a few such adjustments was for n = 15, the last line (in

bold type) in the table. Therefore I am submitting as my answer $N = 2^{10} \cdot 3^4 \cdot 5^2 \cdot 7^2 \cdot 11 \cdot 13 \cdot 17 \cdot 19 \cdot 23 \cdot 29 \cdot 31 \cdot 37 \cdot 41 \cdot 43 \cdot 47$, which has 1,013,758 factors; N = 297,508,272,408,041,611,752,400.

Also solved by Peter Kerr, Glenn Brown, Jeffrey Wint, P. Lyons, R. Robinson Rowe, Sheldon Katz, Roger Milkman, Frank Carbin, Edward Lynch, Frank Rubin, Emmet Duffy, Doug Szper, and the proposer, Theodore Engle.

M/A 3 H. R. ("Tim") Lefever, farmer, environmentalist, and electrical engineer (M.I.T. '41), has an unforgettable phone number, whose digits can be represented as (abc) efg-wxyz. If anyone needs to telephone Lefever to inquire about his solar-heated house, built in 1954, one needs only to remember the following:

☐ The area-code (abc) is a palindrome the sum of whose digits is the square root of the exchange number (efg).

☐ The exchange number (efg) is the square of the sum of the last three digits of the phone number (wxyz).

☐ The last three digits of the phone number (xyz) are consecutive numbers, increasing order, and the sum of the cube of the first three equals the cube of the last.

Despite a minor typo in the problem statement, many readers were able to correctly solve this one. I presume that Mr. Lefever's phone has been quite busy. The following solution is from John Rule:

Consider wxyz; xyz are consecutive numbers such that $w^3 + x^3 + y^3 = z^3$, or $z^3 - (x^3 + y^3) = w^3$.

Hence we want three consecutive numbers such that the cube of the largest minus the cubes of the two smallest yields a number which is itself a cube. A short inspection shows that there is only one such combination: $6^3 - (5^3 + 4^3) = 3^3$. Hence wxyz = 3456; efg = $(4 + 5 + 6)^2 = 225$; and the sum of the digits of abc = 15.

My definition of a palindrome is that it is any number, word, sentence, or what have you, that reads the same forwards as backwards. Unless there is some further restriction of which I am unaware there are five palindromes whose digits add to fifteen: 393, 474, 555, 636, and 717. To get out of this dilemma I must resort to the fact that all the area codes the good A.T.&T. has yet assigned have either a 1 or a 0 as their central digit. This leaves only 717, so I must infer that Mr. Lefever's telephone number is 717-225-3456 and that he lives on a farm in Pennsylvania.

Also solved by: Peter Kerr, Christopher Roth, Ronnie Rybstein, Jeffrey Wint, Glenn Brown, Mike Bercher, Harry Zaremba, Bill Taylor, Winthrop Leeds, P. Jung, Nancy Hall, Elizabeth Sawyer-Klaeson, Rex Ingraham, William Butler, R. Robinson Rowe, P. Lyons, Johan Norvik, Steve Grant, Roger Milkman, Gardner Perry, Patsy Henry, James Sheare, Edward Lynch, John Prussing, Turner Gilman, Naomi Markovitz, Frank Rubin, Doug Szper, Dawn Swift, and the proposer, Neil Hopkins.

n	e_i	N	F
1	1000001	1.98E301030	1,000,000
2	1258, 793	1.13E757	999,644
3	153, 96, 65	1.96E137	985,908
4	56, 35, 23, 19	4.90E65	984,948
5	31, 19, 13, 11, 8	1.29E45	967,678
6	22, 13, 9, 7, 6, 5	7.07E36	1,081,918
7	17, 10, 7, 5, 4, 4, 3	7.54E33	2,851,198
8	14, 9, 5, 4, 3, 3, 3, 2	1.25E28	863,998
9	12, 7, 5, 4, 3, 3, 2, 2, 2	1.08E28	1,347,838
10	11, 6, 4, 3, 2, 2, 2, 2, 2, 1	1.05E25	816,478
11	10, 6, 4, 3, 2, 2, 2, 2, 1, 1, 1	7.06E24	997,918
12	9, 5, 3, 3, 2, 2, 2, 1, 1, 1, 1, 1	4.58E23	829,438
13	9, 5, 3, 2, 2, 2, 1, 1, 1, 1, 1, 1, 1	1.58E23	829,438
14	8, 5, 3, 2, 2, 2, 1, 1, 1, 1, 1, 1, 1, 1	3.39E24	1,492,990
15	8, 5, 3, 2, 2, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1	1.23E25	1,990,654
16	8, 5, 3, 2, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1	5.91E25	2,654,206
17	8, 4, 3, 2, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1	1.16E27	4,423,678
15	10, 4, 2, 2, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1	2.975E23	1,013,758

M/A 4 Consider a solitaire card game (called accordion, among other names, which consists of dealing a deck, one card at a time, and then examining sets of four cards. If the four cards are of the same suit, the middle two are discarded. If the four cards are of the same value, all four are discarded. What are the odds of winning (no cards left)? What if the whole deck is laid out before starting?

No one solved this completely. P. Lyons feels that if the game is restricted to one pass through the deck the probability of success is

$$\frac{2^{42}}{51! - 13!}$$

Jerrold Grossman offered the following comments:

As described, the game is almost impossible to win, although an analytic answer to the first question posed is probably possible. In the version with which I am familiar, the four cards are removed if the first and the fourth are of the same value, while the middle two are discarded if the first and the fourth are of the same suit. Now an analytic solution is next to impossible, but I offer the following data from a computer simulation of 10,000 games, requiring 22 minutes on a Burroughs 5500. Assuming my random number generator "worked," the probability of winning is around .0054 with a standard error of estimation of .0007. Actually the median number of cards remaining at the end of the game turned out to be 14; the mode was 12 (occurring 1014 times); the mean was 14.22 and the standard deviation was 7.59. In the worst game there were 42 cards left at the end.

M/A 5 It is well known that the trigonometric functions of certain spiral angles are algebraic numbers. For example, $\sin 45° = \sqrt{2}/2$, $\sin 15° = \frac{1}{4}(\sqrt{6} - \sqrt{2})$. What is the smallest integer angle A for which such an explicit closed-form expression for sin A may be obtained?

We should have been more precise. By "closed form" we meant "solvable by radicals" or "expressible in surds." It is fitting that our last solution for academic 1977-1978 comes from R. Robinson Rowe:

I note first that algebraics for sin, cos and, tan of multiples of 15° and 18° have been published (e.g., Carr's *Synopsis of Pure Mathematics*). These can be extended by formulae for sines of half angles and difference of two angles. Thus:

$$\sin 3° = \sin (18° - 15°) =$$

$$(\sqrt{5} - 1)/4 \cdot (\sqrt{3} + 1)/2\sqrt{2}$$

$$- (\sqrt{3} - 1)/2\sqrt{2} \cdot \sqrt{5 + \sqrt{5}/2\sqrt{2}}$$

in which I have preserved the expressions for functions of 15° and 18°. Little simplification results from multiplying it out. We cannot get down to 2° or 1° without trisecting an angle. The geometric problem is known to be impossible.

Algebraically, it requires the solution of a cubic with three real roots, which is known to be impossible in surds. Hence the answer is 3°, and the result can be stated more generally: if A is an angle of an integral number of degrees, its sine can be expressed algebraically if and only if A is divisible by 3.

Also solved by: William Butler, Sidney Kravitz, Sheldon Katz, Harry Zaremba, Norman Megill, Naomi Markovitz, Frank Rubin, and the proposer, Stephen Hirshman.

Better Late Than Never

1977 DEC 2 John Allen submits the following:

Please note that there is an additional discrepancy between Mr. Shearer's and Mr. Hartford's solutions to the DEC 2 problem not mentioned in the discussion in the March/April issue. Mr. Shearer assumes that the piston has no mass but that the gas has mass. Otherwise, the dissipative processes (wave motions and shocks) which he mentions would not occur — not as mechanical processes, in any case. If one were to consider electromagnetic radiation confined within perfectly conducting walls and its radiation pressure, wave motion would be in the nature of things, but shocks would not be possible. However, there would be no dissipation within the medium, only within the walls — that is, if the walls were *not* perfectly conducting. This is an example of a case in which the "gas" is indeed massless. Mr. Hartford makes the distinction between a piston with and without mass. But his conditions for a solution given a piston without mass are still not sufficient, because he does not say whether or not the gas has mass. If it does, energy can indeed be stored in the gas itself, and the process will not be instantaneous. There will be oscillations within the gas at both ends of the piston. Consequently, the piston, too, will oscillate. The same is true, of course, even if the piston does have mass.

The conclusion I reach is: science is objective. I think this has been said before — the solution depends on how many factors you are willing and able to bring to bear in analyzing the problem. No solution given so far to the DEC 2 problem is exhaustive, and none, in fact, ever will be. We can set artificial conditions, like perfectly insulating walls, to simplify the problem, but even so, difficulties creep in.

DEC 3 Raymond Cowen and Alan Walter have responded.

Dec 4 R. Boas, the editor of the *American Mathematical Monthly*, notes that a paper on this subject by H. Gould will appear in the June-July issue.

DEC 5 John Rule noted that two quantities were omitted from the diagram:

$L = \overline{CB}$ and $S = \overline{PB}$.

Additional responses have been received: FEB 1, FEB 2, and FEB 3 Frank Rubin.

FEB 4 Frank Rubin, Warren Lane, and R. Robinson Rowe.

FEB 5 Frank Rubin.

Proposer's Solutions to Speed Problems

SD 1 2½ ohms.

SD 2 ½ ohm.

Prices: Easy Up, Sticky Down

Inflation — the persistent downward trend in the purchasing power of money — feeds on itself: an expectation of increasing prices is self-fulfilling, as we all protect ourselves today against the prices we expect to have to pay for things tomorrow.

That's the central fact about inflation, says Robert M. Solow, Professor of Economics at M.I.T.: it explains why inflation has happened so easily to the American economy since World War II and why — despite recessions and growing unemployment — deflation has almost never happened.

Another way of saying the same thing, according to Professor Solow in his James R. Killian Faculty Achievement Lecture at M.I.T. this spring: there is an "unfavorable" trade-off between unemployment and inflation, such that a 1-per-cent drop in employment yields only an 0.5-per-cent drop in prices.

One reason for this is the "cushion of unemployment insurance and compensation" which has been put in place in the U.S. primarily since World War II. That comment doesn't mean Professor Solow opposes such programs; they are "good social instruments," he said, with some "unexpected side effects."

Another hypothesis: ever since the Great Depression of the 1930s economists have proclaimed their confidence that such disasters need not and will not happen in the future. But our present persistent inflation may be a side effect of that confidence: if a recession is certain to be mild and short, then only its few victims will lose confidence in the system and reduce their purchases.

In short, said Professor Solow on "What We Know and Don't Know About Inflation," there are "no easy answers. Diddling away at the problem may be the best we can do." — *J.M.* □

Nuclear Outbursts on Neutron Stars

The sky above the earth's atmosphere is bright with x-rays from throughout our Milky Way galaxy. Among the sources are the "pulsars," which emit pulses of x-radiation at periodic intervals ranging from a fraction of a second up to several minutes, and the "bursters" — sources of immensely energetic, short bursts of x-rays that contain the power of 100,000 suns. The x-ray pulsars have been attributed to neutron stars; but the bursters are more mysterious, and exotic explanations invoking black holes have been proposed by some astrophysicists. Now Professor Paul C. Joss of M.I.T. has advanced a theory that links the bursters, too, to neutron stars.

A neutron star is the residue of an ordinary star whose nuclear fuel has been exhausted so that it collapses after a great explosion, to form an extremely dense body with an exceedingly strong gravitational field. These objects are sometimes found to be in orbit around conventional stars. The x-rays characteristic of pulsar are presumably generated as matter is expelled by the companion star and is drawn at very high speed onto the neutron star (*see "Trend of Affairs" for January, page 83*).

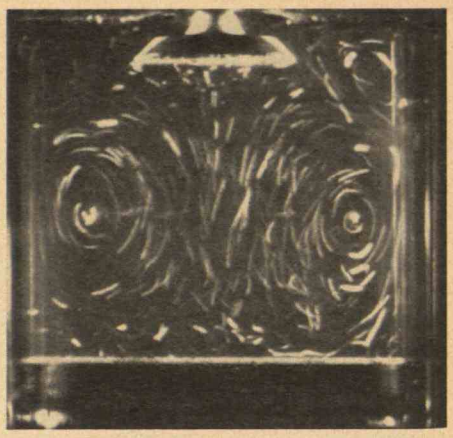
In a letter to *The Astrophysical Journal*, Professor Joss suggests a similar source for the bursters. In this case, the falling matter accumulates until it becomes extremely hot and dense, and then the atomic nuclei begin to fuse together in much the same way as in a thermonuclear bomb. The energy released in this "thermonuclear flash" results in the burst of x-rays. Professor Joss has calculated numerical models of thermonuclear flashes, and he finds "amazing agreement" between these and the burster observations; so he concludes that another link between cosmic x-radiation and neutron stars is in place. □

What's Been Overlooked in Basic Energy

When you think of energy you think of oil, gas, coal, electricity, perhaps the sun, maybe the tides . . . of boilers, furnaces, reactors, collectors, turbines, and generators. Do we really know as much as we should about all these systems and devices? Are we missing some bets for the future because today's knowledge is inadequate?

Thomas F. Jones, M.I.T. Vice President for Research, says that physicists and engineers should be busy taking "a completely new look at all energy" processes "to see what's been overlooked in basic knowledge.

"We've never even really taken a complete cataloguing of what's there," Professor Jones told *Chronicle of Higher Education* in a Sun Day interview late last spring. "We need to go back and re-search in its truest sense," he said. □



Beads suspended in liquid show the pattern of motion during the intake stroke of an experimental cylinder. The more motion in such a cylinder at the time the spark ignites the gas/air mixture in it, the more power (and more economy) from an internal combustion engine. (Photo: M.I.T. Energy Laboratory)

How to Blow Up a Storm in an Engine

The more turbulent the mixture of gas in the cylinder of an internal combustion engine, the faster the burning of that mixture when ignited by the spark plug — and the more powerful the explosion. The catch is that measuring turbulence at the moment of ignition seems to be impossible.

But turbulence in the cylinder at "bottom dead center" — when the piston is at the bottom of the cylinder and compression is about to begin — can in fact be measured. And now Professor David P. Hoult of the Department of Mechanical Engineering has extrapolated from such data to make a model by which to predict the state of the gases at the time of ignition. If the model proves to be accurate, the next stage of Professor Hoult's research will be to change cylinder shapes and firing times in search of maximum turbulence, leading to maximum power, maximum economy, and minimum emissions. □

A New Lightweight Alloy

Aluminum and lithium do not naturally mix, but when rapidly chilled from a melt by a process called "splat cooling," they form a new alloy which is stronger and lighter than other aluminum-based combinations. □

"Splat cooling" involves throwing droplets of a molten metal — in this case the appropriate mixture of lithium and aluminum — against a much cooler metal surface with extremely high heat conductivity. The droplets go "splat" into flakes no thicker than .004 inch, with cooling rates as high as 10 billion degrees C. per second. Once made in this way, the flakes can be reheated and extruded to produce "a very fine-grained crystalline structure which is dense and sound," says Nicholas J. Grant, ABEX Professor for Advanced Materials at M.I.T.

Professor Grant thinks the new alloy — because of its greater strength, lighter weight, and better resistance to fatigue — will find a place in the aircraft industry. His work was supported by the National Science Foundation, which announced these results early this summer. □

How to Guarantee Nonproliferation . . .

If the U.S. wants to minimize world trade in plutonium, let it guarantee uranium to nations with commitments to nuclear power. Otherwise such nations will have no choice but to proceed with building plants to recycle spent reactor fuel, one product of which is plutonium.

The incentives are simple enough to understand, say Professors George W. Rathjens and Carroll L. Wilson in an editorial contribution to the *Christian Science Monitor*. A modern nuclear plant may cost up to $1 billion, and once it is built tens of thousands of jobs as well as the return on the original investment will depend on the continuity of its power production; an investment in reprocessing technology to guarantee that continuity will be very easy for any nation to justify.

In contrast, a 30-year supply of fuel for such a reactor — about 4,500 tons of uranium — is worth at today's prices only $270 million. Set aside now by the four countries with most of the world's uranium — Australia, Canada, South Africa, and the U.S. — that uranium stockpile would be inexpensive insurance against proliferation.

. . . but Proliferation is Picayune

International debate about the dangers of proliferation (*see above*) is distracting world leaders from the real problem, which is the same as it has been for the last 25 years — only more so: the ever-escalating nuclear arms race.

Don't forget, writes Victor F. Weisskopf, Institute Professor Emeritus at M.I.T., in the *New York Times:* "The Soviet Union and the U.S. have deployed more than 50,000 nuclear bombs. . . . Even the detonation of a single weapon of modern design over a city would be a catastrophy unprecedented in human history. . . . Yet (these) two large countries keep assembling more and more of these horrendous means of annihilation . . . for all sorts of imagined missions . . . simply because they do not know how and where to stop.

"It is the ultimate of irrationality and antilogic, the triumph of craziness.

"The nuclear power controversy dwindles to picayune dimensions compared to this overwhelming threat . . . The reduction and eventual abolition of nuclear weapons must have absolute priority," insists Professor Weisskopf. □

An Economic Model of Nodule Recovery

Don't write off the sea-floor manganese nodules as a mineral resource yet. A recent study by Professor J. Daniel Nyhart postulates an internal rate of return of up to 15 to 22 per cent on corporate investments in this technology.

Professor Nyhart — he's a lawyer who teaches in the Department of Ocean Engineering and Sloan School of Management — has a computer-based model which shows the cost and income of deep-sea mining enterprises under various assumptions about the U.S. metal market and international regulation. For example, the simplest first-generation operation using a single mineship would have annual operating cost (once in commercial production, six years after the initial investment is made) of $101 million and gross revenues $258 million from 3 million tons of nodules. □

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A Welfare Program for Real Welfare

True or false: The U.S. welfare system is burdened by a major commitment to the needs of a hard-core "welfare class" of unemployed — and perhaps unemployable — people.

False, say Professors Martin Rein of M.I.T. and Lee Rainwater of Harvard in a report from the Harvard-M.I.T. Joint Center for Urban Studies.

There are such hard-core dependents on welfare, Professors Rein and Rainwater admit; but they number less than 10 per cent of all the people served by the welfare system and only a little over 20 per cent of those on welfare at any one time.

The urban experts' conclusion is that the so-called "work-disincentive" aspects of welfare programs have been greatly exaggerated. For the vast majority, they say, what is needed is more assistance to the working poor rather than elaborate incentives to look for work. "Although 20 per cent of welfare recipients in a given year consume as much as 60 per cent of the welfare dollars," says Professor Rein, "it might be more useful to concentrate policymaking efforts on the 80 per cent who use welfare only part of the time." □

Toward Open Shops in the Construction Industry

Though union firms still dominate high-rise commercial building and highway construction, open shop non-union firms — which have traditionally done most U.S. small-scale and commercial building — are moving into the "superprojects."

The villain for the unions has been the volatility of the construction industry — unparalleled cycles of expansion and depression — since World War II; in slack times, the unions simply could not support their members. The construction industry has been changing, too, with the adoption of new technologies requiring less skill on the site.

But the trend away from union firms may have gone about as far as it can go, say Professors Raymond E. Levitt of the M.I.T. Department of Civil Engineering and Clinton C. Bourdon of the Harvard Business School. Unions are becoming more competitive, adjusting wages and work rules to help their members keep their jobs. And whenever union and non-union firms are in direct competition — as they increasingly are — they are forced to become more like each other.

Professors Levitt and Bourdon based their study on a survey of construction industry in eight metropolitan areas — Boston, Baltimore, Atlanta, New Orleans, Kansas City, Grand Rapids, Denver, and Portland (Ore.) — in cooperation with the Economics Department of the National Association of Home Builders. □

ENERGY FOR WHAT?

We Americans have been warned repeatedly: we cannot expect to go on living the way we did in 1973 before the OPEC oil embargo. Things are going to be different in 1985 and by the year 2000, we are told, they'll be dramatically different.

The clear implication, of course, is that things will be rough in 1985 and worse by 2000. Life will be meaner. And, if not less to live for, there will be less to hope for.

Even though that prospect is both dim and questionable, it has faced only the most desultory challenges. Instead, debate has centered around the proper tactics to postpone Doomsday, the most likely date on which Doomsday will occur should we fail to agree on how to delay it, how much profit if any should be permitted those who keep the wheels humming until then, and other questions similarly remote from the basic issue.

The basic issue, it seems to us, is not Conservation versus Development, not Environment versus Energy, not Soft-Paths versus Hard. What matters most is not whether the higher price of oil goes to the producers as profit or the Government as taxes—nor even that the consumer pays the same regardless. The issue is that *none of the alternatives being argued is relevant if all it can promise is to slow our slide downhill.*

What is being exposed in this long, drawn-out haggling over Energy Policy may not be the short-fall of our resources, nor the weakness of our will, nor the inefficiency of our democracy. What is being exposed may be the paucity of our vision.

We Americans never expected to go on living the way we did in 1973 before the embargo. We expected each year to be sufficient unto itself and each one to be different.

What do we expect of 1985? Of the year 2000? What, for that matter, do we expect of 1980? Certainly not to be still arguing the issues of 1978!

Quite simply and matter-of-factly, we cannot begin to resolve the question of Energy without first resolving the question of "Energy for What?"

What kind of a country do we want to live in? What kind of a society do we intend to build? What kind of a world do we wish to shape?

Are we ready to retire from world leadership? Have we lost our faith in progress and exploration? Have we run out our string of dreams—dreams that were so palpable in the past and seem so elusive today? Or do we still have "promises to keep"?

Is the world's most highly-developed nation ready to shift into neutral gear while its plants and equipment coast into obsolescence, its technology languishes, and its buildings deteriorate toward landmark status or await conversion by the arsonist into insurance claims?

"The cause of America," Tom Paine wrote in *Common Sense,* "is the cause of the whole world." Isn't it still?

More than energy policies upon which to build a vision of the future, we need a vision of the future upon which to build our energy policies.

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With that in mind, we have invited a number of distinguished thinkers to join us in a continuing exploration of the question "Energy for What?" Because the issue goes to the heart of what this nation stands for it belongs, quite properly, to all the American people. For that reason, we are taking the unusual step of carrying our concerns beyond the confines of our membership through this and other thoughtful publications.

We welcome your comments and invite your inquiries.

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On September 12, 1978, Senators Dewey F. Bartlett and James Abourezk, distinguished members of the Committee on Energy and Natural Resources, will join Herman Kahn, director of the Hudson Institute, to present their views on "Energy for What?" This luncheon meeting for members and guests is the first in a series of explorations we are planning on this subject. For further information:

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Before computers, engineering designs were evaluated the hard way. They were built, tested, modified, retested, remodified — and so on.

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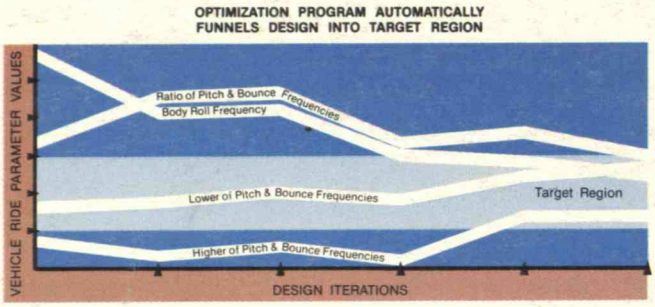

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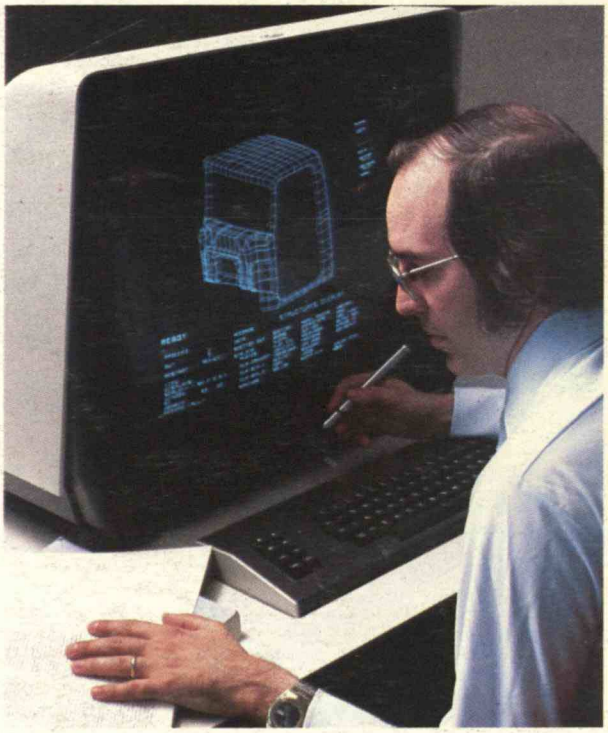

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